FISHES

DAVID STARR JORDAN

GUIDE TO THE STUDY OF FISHES

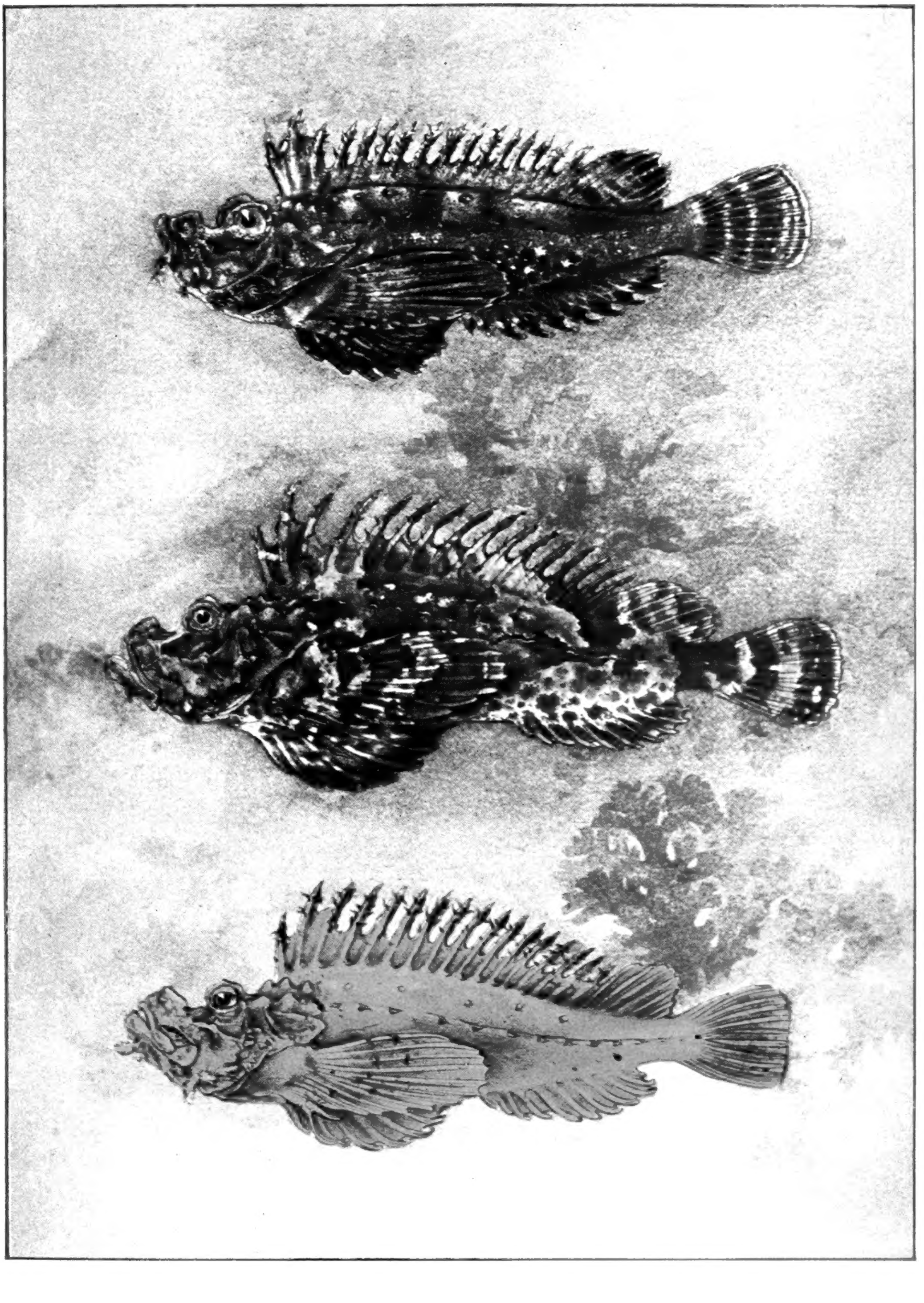
VARIATIONS IN THE COLOR OF FISHES

The Oniokose or Demon Stinger, *Inimicus japonicus* (Cuv and Val.), from Wakanoura, Japan. From nature by Kako Morita.

Surface coloration about lava rocks.

Coloration of specimens living among red algæ.

Coloration in deep water; *Inimicus aurantiacus* (Schlegel).



A GUIDE

TO

THE STUDY OF FISHES

BY

DAVID STARR JORDAN

President of Leland Stanford Junior University

With Colored Frontispieces and 507 Illustrations

IN TWO VOLUMES

VOL. II.

"I am the wiser in respect to all knowledge and the better qualified for all fortunes for knowing that there is a minnow in that brook."—*Thoreau*

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CONTENTS

VOL. II.

CHAPTER I.

THE GANOIDS.

CHAPTER II.

THE GANOIDS (*Continued*).

CHAPTER III.

ISOSPONDYLI.

CHAPTER IV.

SALMONIDÆ.

CHAPTER V.

SALMONIDÆ (*Continued*).

CHAPTER VI.

THE GRAYLING AND THE SMELT.

CHAPTER VII.

THE APODES, OR EEL-LIKE FISHES.

CHAPTER VIII.

SERIES OSTARIOPHYSI.

CHAPTER IX.

THE NEMATOGNATHI, OR CATFISHES.

CHAPTER X.

THE SCYPHOPHORI, HAPLOMI, AND XENOMI.

CHAPTER XI.

ACANTHOPTERYGII; SYNENTOGNATHI.

CHAPTER XII.

PERCESOCES AND RHEGNOPTERI.

CHAPTER XIII.

PHTHINOBRANCHII: HEMIBRANCHII, LOPHOBRANCHII, AND HYPOSTOMIDES.

CHAPTER XIV.

SALMOPERCÆ AND OTHER TRANSITIONAL GROUPS.

CHAPTER XV.

BERYCOIDEI.

CHAPTER XVI.

PERCOMORPHI.

CHAPTER XVII.

CAVALLAS AND PAMPANOS.

CHAPTER XVIII.

PERCOIDEA, OR PERCH-LIKE FISHES.

CHAPTER XIX.

THE BASS AND THEIR RELATIVES.

CHAPTER XX.

THE SURMULLETS, THE CROAKERS AND THEIR RELATIVES.

CHAPTER XXI.

LABYRINTHICI AND HOLCONOTI.

CHAPTER XXII.

CHROMIDES AND PHARYNGOGNATHI.

CHAPTER XXIII.

THE SQUAMIPINNES.

CHAPTER XXIV.

SERIES PLECTOGNATHI.

CHAPTER XXV.

PAREIOPLITÆ, OR MAILED-CHEEK FISHES.

CHAPTER XXVI.

GOBIOIDEI, DISCOCEPHALI, AND TÆNIOSOMI.

LIST OF ILLUSTRATIONS

VOL. II.

ERRATA*

Vol. II

Page xviii, line 7, for *Ophicæphalus* read *Ophicephalus*
xviii, " 37, for *Mononactylus* read *Monodactylus*
xix, " 33, for *Trachicephales* read *Trachicephalus*
xx, " 37, for *Regaleaus glesneacsanius* read *Regalecus russelli*
xxi, " 2, for *Etopus* read *Etropus*
xxi, " 35, for *Zoacres* read *Zoarces*
1, " 7, *for* jaws *read* jaw
14, " 9, *for* hetercoercal *read* heterocercal
136, " 3, for *Evermannellus* read *Evermannella*
170, " 11, *for* the fin *read* the dorsal fin
171, " 10, *for* have *read* has
303, legend, *for* Lacepède *read* Lacépède
307, line 14, *for* vertebrate *read* vertebral
311, " 12, not clearly stated. The air-bladder is least developed in those species which cling closest to the bottom of the stream
350, legend, for *Apomotes* read *Apomotis*
355, line 18, *for* ours *read* our
357, " 14, *for* chætodon *read* Chætodon
358, " 17, for *Scriænidæ* read *Sciænidæ*
360, " 14, for *Percesoces* read Percesoces
409, " 16, for *naseus* read *Naseus*
419, " 23, *for* of the generic of this group *read* separating the group into genera
440, " 17, *for* Chinnook *read* Chinook
459, " 24, *for* but the most *read* but most
459, " 25, *for* thme *read* them
467, " 14, for *Typhogobius* read *Typhlogobius*
472, lines 34, 35, *omit* "but never in the United States". Specimens of *Regalecus* have been taken at Anclote Key, Florida, and at the Tortugas.
580, col. 3, line 17, *for* 165 *read* 105

The adoption of the Code of the International Congress of Zoology necessitates a few changes in generic names used in this book.

Thus *Amia* (ganoid)	becomes *Amiatus*
Apogon	becomes *Amia*
Scarus	becomes *Callyodon*
Teuthis	becomes *Hepatus*
Acanthurus	becomes *Monoceros*
Paramia	becomes *Cheilodipterus*
Centropomus (*Oxylabrax*)	remains *Centropomus*
Lucioperca (*Centropomus*)	becomes *Sander*
Pomatomus (*Cheilodipterus*)	remains *Pomatomus*
Nomeus (*Gobiomorus*)	remains *Nomeus*
Galeus (*Galeorhinus*)	remains *Galeus*
Carcharias (*Carcharhinus*)	remains *Carcharias*

* For most of this list of errata I am indebted to the kindly interest of Dr. B. W. Evermann.

CHAPTER I

THE GANOIDS

SUBCLASS **Actinopteri.** — In our glance over the taxonomy of the earlier Chordates, or fish-like vertebrates, we have detached from the main stem one after another a long series of archaic or primitive types. We have first set off those with rudimentary notochord, then those with retrogressive development who lose the notochord, then those without skull or brain, then those without limbs or lower jaws. The residue assume the fish-like form of body, but still show great differences among themselves. We have then detached those without membrane-bones, or trace of lung or air-bladder. We next part company with those having the air-bladder a veritable lung, and those with an ancient type of paired fins, a jointed axis fringed with rays, and those having the palate still forming the upper jaw. We have finally left only those having fish-jaws, fish-fins, and in general the structure of the modern fish. For all these in all their variety, as a class or subclass, the name *Actinopteri*, or *Actinopterygii*, suggested by Professor Cope, is now generally adopted. The shorter form, *Actinopteri*, being equally correct is certainly preferable. This term (ακτίς, ray; πτερόν or πτερύξ, fin) refers to the structure of the paired fins. In all these fishes the bones supporting the fin-rays are highly specialized and at the same time concealed by the general integument of the body. In general two bones connect the pectoral fin with the shoulder-girdle. The hypercoracoid is a flat square bone, usually perforated by a foramen. Lying below it and parallel with it is the irregularly formed hypocoracoid. Attached to them is a row of bones, the actinosts, or pterygials, short, often hour-glass-shaped, which actually support the fin-rays. In the more specialized forms, or Teleosts, the actinosts are few (four to six) in number,

but in the more primitive types, or Ganoids, they may remain numerous, a reminiscence of the condition seen in the Crossopterygians, and especially in *Polypterus*. Other variations may occur; the two coracoids sometimes are imperfect or specially modified, the upper sometimes without a foramen, and the actinosts may be distorted in form or position.

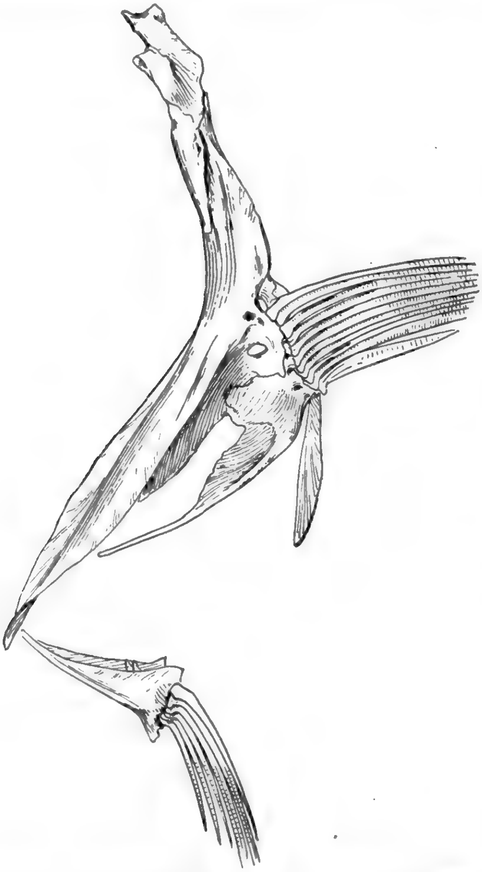


FIG. 1.—Shoulder-girdle of a Flounder, *Paralichthys californicus* (Ayres).

The Series Ganoidei.—Among the lower *Actinopteri* many archaic traits still persist, and in its earlier representatives the group approaches closely to the *Crossopterygii*, although no forms actually intermediate are known either living or fossil. The great group of *Actinopteri* may be divided into two series or subclasses, the *Ganoidei*, or *Chrondrostei*, containing those forms, mostly extinct, which retain archaic traits of one sort or another, and the *Teleostei*, or bony fishes, in which most of the primitive characters have disappeared. Doubtless all of the *Teleostei* are descended from a ganoid ancestry.

Even among the *Ganoidei*, as the term is here restricted, there remains a very great variety of form and structure. The fossil and existing forms do not form continuous series, but represent the tips and remains of many diverging branches perhaps from some Crossopterygian central stock. The group constitutes at least three distinct orders and, as a whole, does not admit of

perfect definition. In most but not all of the species the tail is distinctly and obviously heterocercal, the lack of symmetry of the tail in some Teleosts being confined to the bones and not evident without dissection. Most of the Ganoids have the skeleton still cartilaginous, and in some it remains in a very primitive condition. Usually the Ganoids have an armature of bony plates, diamond-shaped, with an enamel like that developed on the teeth. In all of them the pectoral fin has numerous basal bones or actinosts. All of them have the air-bladder highly developed, usually cellular and functional as a lung, but connecting with the dorsal side of the gullet, not with the ventral side as in the Dipnoans. In all living forms there is a more or less perfect optic chiasma. These ancient forms retain also the many valves of the arterial bulb and the spiral valve of the intestines found in the more archaic types of fishes. But traces of some or all of these structures are found in some bony fishes, and their presence in the Ganoids by no means justifies the union of the Ganoids with the sharks, Dipnoans, and Crossopterygians to form a great primary class, *Palæichthyes*, as proposed by Dr. Günther. Almost every form of body may be found among the Ganoids. In the Mesozoic seas these fishes were scarcely less varied and perhaps scarcely less abundant than the Teleosts in the seas of to-day. They far exceed the Crossopterygians in number and variety of forms. Transitional forms connecting the two groups are thus far not recognized. So far as fossils show, the characteristic actinopterous fin with its reduced and altered basal bones appeared at once without intervening gradations.

The name *Ganoidei* (γάνος, brightness; εἶδος, resemblance), alluding to the enameled plates, was first given by Agassiz to those forms, mostly extinct, which were covered with bony scales or hard plates of one sort or another. As the term was originally defined, mailed catfishes, sea-horses, *Agonidæ*, *Arthrodires*, *Ostracophores*, and other wholly unrelated types were included with the garpikes and sturgeons as Ganoids. Most of these intruding forms among living fishes were eliminated by Johannes Müller, who recognized the various archaic characters common to the existing forms after the removal of the mailed Teleosts. Still later Huxley separated the Crossopterygians as a distinct

group, while others have shown that the *Ostracophori* and *Arthrodira* should be placed far from the garpike in systematic classification. Cope, Woodward, Hay, and others have dropped the name Ganoid altogether as productive of confusion through the many meanings attached to it. Others have kept it as a convenient group name for the orders of archaic *Actinopteri*. For these varied and more or less divergent forms it seems convenient to retain it. As an adjective "ganoid" is sometimes used as descriptive of bony plates or enameled scales, some-in the sense of archaic, as applied to fishes.

Are the Ganoids a Natural Group? — Several writers have urged that the *Ganoidei*, even as thus restricted, should not be considered as a natural group, whether subclass, order, or group of orders. The reasons for this view in brief are the following:

1. The group is heterogeneous. The *Amiidæ* differ more from the other Ganoids than they do from the herring-like Teleosts. The garpikes, sturgeons, paddle-fishes likewise diverge widely from each other and from the *Palæoniscidæ* and the *Platysomidæ*. Each of the living families represents the residue or culmination of a long series, in some cases advancing, as in the case of the bowfin, sometimes perhaps degenerating, as in the case of the sturgeons.

2. Of the traits possessed in common by these forms, several (the cellular air-bladder, the many valves in the heart, the spiral valve in the intestine, the heterocercal tail) are all possessed in greater or less degree by certain *Isospondyli* or allies of the herring. All these characters are still better developed in *Crossoptergyii* and *Dipneusti*, and each one disappears by degrees. Of the characters drawn from the soft parts we can know nothing so far as the extinct Ganoids are concerned.

3. The optic chiasma, thus far characteristic of Ganoids as distinct from Teleosts, may have no great value. It is urged that in closely related species of lizards some have the optic chiasma and others do not. This, however, proves nothing as to the value of the same character among fishes.

4. The transition from Ganoids to Teleosts is of much the same character as the transition from spiny-rayed to soft-rayed fishes, or that from fishes with a duct to the air-bladder to those without such duct.

Admitting all this, it is nevertheless natural and convenient to retain the Ganoidei (or *Chrondrostei* if the older name be discarded on account of the many meanings attached to it) as a group equivalent to that of *Teleostei* within the class or subclass of *Actinopteri*. It comprises the transitional forms between the *Crossopterygii* and the bony fishes, and its members are especially characteristic of the Mesozoic age, ranging from the Devonian to the present era.

Of the extensive discussion relating to this important question we may quote two arguments for the retention of the subclass of Ganoids, the first by Francis M. Balfour and William Kitchen Parker, the second from the pen of Theodore Gill.

Balfour and Parker ("Structure and Development of Lepidosteus," pp. 430–433) thus discuss the

Systematic Position of Lepidosteus.—"Alexander Agassiz concludes his memoir on the development of *Lepidosteus* by pointing out that in spite of certain affinities in other directions this form is 'not so far removed from the bony fishes as has been supposed.' Our own observations go far to confirm Agassiz's opinion.

"Apart from the complete segmentation, the general development of *Lepidosteus* is strikingly Teleostean. In addition to the general Teleostean features of the embryo and larva, which can only be appreciated by those who have had an opportunity of practically working at the subject, we may point to the following developmental features * as indicative of Teleostean affinities:

"(1) The formation of the nervous system as a solid keel of the epiblast.

"(2) The division of the epiblast into a nervous and epidermic stratum.

"(3) The mode of development of the gut.

"(4) The mode of development of the pronephros; though the pronephros of *Lepidosteus* has primitive characters not retained by Teleostei.

"(5) The early stages in the development of the vertebral column.

* The features enumerated above are not in all cases confined to *Lepidosteus* and Teleostei, but are always eminently characteristic of the latter.

"In addition to these, so to speak, purely embryonic characters there are not a few important adult characters:

"(1) The continuity of the oviducts with the genital glands.

"(2) The small size of the pancreas, and the presence of numerous so-called pancreatic cæca.

"(3) The somewhat coiled small intestine.

"(4) Certain characters of the brain, e.g., the large size of the cerebellum; the presence of the so-called lobi inferiores on the infundibulum, and of tori semi-circulares in the mid-brain.

"In spite of the undoubtedly important list of features to which we have just called attention, a list containing not less important characters, both embryological and adult, separating *Lepidosteus* from the Teleostei, can be drawn up:

"(1) The character of the truncus arteriosus.

"(2) The fact of the genital ducts joining the ureters.

"(3) The presence of vasa efferentia in the male carrying the semen from the testes to the kidney, and through the tubules of the latter into the kidney-duct.

"(4) The presence of a well-developed opercular gill.

"(5) The presence of a spiral valve; though this character may possibly break down with the extension of our knowledge.

"(6) The typical Ganoid characters of the thalamencephalon and the cerebral hemispheres.

"(7) The chiasma of the optic nerves.

"(8) The absence of a pecten, and presence of a vascular membrane between the vitreous humor and the retina.

"(9) The opisthocœlous form of the vertebræ.

"(10) The articulation of the ventral parts of the hæmal arches of the tail with the processes of the vertebral column.

"(11) The absence of a division of the muscles into dorso-lateral and ventro-lateral divisions.

"(12) The complete segmentation of the ovum.

"The list just given appears to us sufficient to demonstrate that Lepidosteus cannot be classed with the Teleostei; and we hold that Müller's view is correct, according to which *Lepidosteus* is a true Ganoid.

"The existence of the Ganoids as a distinct group has, however, recently been challenged by so distinguished an ichthy-

ologist as Günther, and it may therefore be well to consider how far the group as defined by Müller is a natural one for living forms, and how far recent researches enable us to improve upon Müller's definitions. In his classical memoir the characters of the Ganoids are thus shortly stated:

"'These fishes are either provided with plate-like angular or rounded cement-covered scales, or they bear osseous plates, or are quite naked. The fins are often, but not always, beset with a double or single row of spinous plates or splints. The caudal fin embraces occasionally in its upper lobe the end of the vertebral column, which may be prolonged to the end of the upper lobe. Their double nasal openings resemble those of Teleostei. The gills are free, and lie in a branchial cavity under an operculum, like those of Teleostei. Many of them have an accessory organ of respiration, in the form of an opercular gill, which is distinct from the pseudobranch, and can be present together with the latter; many also have spiracles like Elasmobranchii. They have many valves in the stem of the aorta like the latter, also a muscular coat in the stem of the aorta. Their ova are transported from the abdominal cavity by oviducts. Their optic nerves do not cross each other. The intestine is often provided with a spiral valve, like Elasmobranchii. They have a swimming-bladder with a duct, like many Teleostei. Their pelvic fins are abdominal.

"'If we include in a definition only those characters which are invariable, the Ganoids may be shortly defined as being those fish with numerous valves to the stem of the aorta, which is also provided with a muscular coat, with free gills, and an operculum, and with abdominal pelvic fins.'

"To these distinctive characters he adds, in an appendix to his paper, the presence of the spiral valve, and the absence of a processus falciformis and a choroid gland.

"To the distinctive set of characters given by Müller we may probably add the following:

"(1) Oviducts and urinary ducts always unite, and open by a common urogenital aperture behind the anus.

"(2) Skull hyostylic.

"(3) Segmentation complete in the types so far investigated,

though perhaps *Amia* may be found to resemble the Teleostei in this particular.

"(4) A pronephros of the Teleostean type present in the larva.

"(5) Thalamencephalon very large and well developed.

"(6) The ventricle in the posterior part of the cerebrum is not divided behind into lateral halves, the roof of the undivided part being extremely thin.

"(7) Abdominal pores always present.

"The great number of characters just given are amply sufficient to differentiate the Ganoids as a group; but, curiously enough, the only characters, amongst the whole series which have been given, which can be regarded as peculiar to the Ganoids are (1) the characters of the brain, and (2) the fact of the oviducts and kidney-ducts uniting together and opening by a common pore to the exterior.

"This absence of characters peculiar to the Ganoids is an indication of how widely separated in organization are the different members of this great group.

"At the same time, the only group with which existing Ganoids have close affinities is the Teleostei. The points they have in common with the Elasmobranchii are merely such as are due to the fact that both retain numerous primitive vertebrate characters,* and the gulf which really separates them is very wide.

"There is again no indication of any close affinity between the Dipnoans and, at any rate, existing Ganoids.

"Like the Ganoids, the Dipnoans are no doubt remnants of a very primitive stock; but in the conversion of the air-bladder into a true lung, the highly specialized character of their limbs,† their peculiar autostylic skulls, the fact of their ventral nasal openings leading directly into the mouth, their multisegmented bars (interspinous bars) directly prolonged from the neural and hæmal and supporting the fin-rays of the unpaired dorsal

* As instances of this we may cite (1) the spiral valve; (2) the frequent presence of a spiracle; (3) the frequent presence of a communication between the pericardium and the body-cavity; (4) the heterocercal tail.

† Vide F. M. Balfour, "On the Development of the Skeleton of the Paired Fins of Elasmobranchs," Proc. Zool. Soc., 1881.

and ventral fins, and their well-developed cerebral hemispheres, very unlike those of Ganoids and approaching the Amphibian type, they form a very well-defined group and one very distinctly separated from the Ganoids.

"No doubt the Chondrostean Ganoids are nearly as far removed from the Teleostei as from the Dipnoans, but the links uniting these Ganoids with the Teleostei have been so fully preserved in the existing fauna of the globe that the two groups almost run into each other. If, in fact, we were anxious to make any radical change in the ordinary classification of fishes, it would be by uniting the Teleostei and Ganoids, or rather constituting the Teleostei into one of the subgroups of the Ganoids, equivalent to the Chondrostei. We do not recommend such an arrangement, which in view of the great preponderance of the Teleostei amongst living fishes would be highly inconvenient, but the step from *Amia* to the Teleostei is certainly not so great as that from the Chondrostei to Amia, and is undoubtedly less than that from the Selachii to the Holocephali."

Gill on the Ganoids as a Natural Group.—Dr. Gill observes ("Families of Fishes," 1872): "The name Ganoides (or Ganiolepedoti) was originally framed by Prof. Agassiz as an ordinal term for fishes having the scales (when present) angular and covered with enamel; and in the group so characterized were combined the Ganoids of subsequent authors as well as the Teleostean orders Plectognathi, Lophobranchii, and Nematognathi, and (subsequently) the genus *Sudis* (*Arapaima*), the last being regarded as a Cœlacanth. The group has not been accepted with these limits or characters.

"But the researches of Prof. Johannes Müller on the anatomy and classification of the fishes culminated at length in his celebrated memoirs on those fishes for which he retained the ordinal name Ganoidei; those memoirs have left an impression on ichthyology perhaps more decided than made by any other contributions to science, and that published *in extenso* will ever be classical; numerous as have been the modifications since introduced into the system, no forms except those recognized by Müller (unless it be Dipnoi) have been interjected since among the Ganoids.

"It has been objected that the Ganoids do not constitute a natural group, and that the characters (i.e., chiasma of optic nerves and multivalvular bulbus arteriosus) alleged by Müller to be peculiar to the teleostomous forms combined therein are problematical, and only *inferentially* supposed to be common to the extinct Ganoids so called, and, finally, such objections couched in too strong language have culminated in the assertion that the characters in question are actually *shared* by other physostome fishes.

"No *demonstration*, however, has been presented as yet that any physostome fishes do really have the optic chiasma and multivalvular *bulbus arteriosus*, and the statement to the contrary seems to have been the result of a venial misapprehension of Prof. Kner's statements, or the offspring of impressions left on the memory by his assertions, in forgetfulness of his exact words.

"But Prof. Kner, in respect to the anatomical characters referred to, merely objects: (1) that they are *problematical*, are not confirmable for the extinct types, and were *probably* not existent in certain forms that have been referred to the Ganoids; (2) the difference in number of the valves of the *bulbus arteriosus* among recent Ganoids is so great as to show the unreliability of the character; (3) a spiral valve is developed in the intestine of several osseous fishes ('genera of the so-called intermediate clupeoid groups'), as well as in Ganoids; and (4) the chiasma of the optic nerves in no wise furnishes a positive character for the Ganoids.

"It will be noticed that all these objections (save in the case of the intestinal spiral valve) are hypothetical and vague. The failure of the intestinal spiral valve, as a diagnostic character, has long been conceded, and in this case only have the forms that *prove* the failure been referred to; in the other cases, where it would be especially desirable to have indicated the actual types falsifying the universality or exclusiveness of the characters, they have not been referred to, and the objections must be met as if they were not known to exist.

"(1) The characters in question are, in the sense used, problematical, inasmuch as no examination can be made of the soft parts of extinct forms, but with equal force may it be

urged that any characters that have not been or cannot be *directly* confirmed are problematical in the case of all other groups (e.g., mammals), and it can only be replied that the coordination of parts has been so invariably verified that all probabilities are in favor of similar coordination in any given case.

"(2) There is doubtless considerable difference in the number of valves of the *bulbus arteriosus* among the various Ganoids, and even among the species of a single family (e.g., *Lepidosteidæ*), but the character of Ganoids lies not in the number, more or less, but in the greater number and relations (in contradistinction to the opposite pair of the Teleosts) in conjunction with the development of a *bulbus arteriosus*. In no other forms of Teleostomes have similar relations and structures been yet demonstrated.

"(3) The failure of the spiral intestinal valve has already been conceded, and no great stress has ever been laid on the character.

"(4) The chiasma of the optic nerves is so common to all the known Ganoids, and has not been found in those forms (e.g., *Arapaima*, *Osteoglossum*, and *Clupeiform* types) agreeing with typical physostome Teleosts in the skeleton, heart, etc., but which at the same time simulate most certain Ganoids (e.g., *Amia*) in form.

"Therefore, in view of the evidence hitherto obtained, the arguments against the validity of title, to natural association, of the Ganoids, have to meet the positive evidence of the coordinations noted; the value of such characteristics and coordinations can only be affected or destroyed by the demonstration that in all other respects there is (1) very close agreement of certain of the constituents of the subclass with other forms, and (2) inversely proportionate dissimilarity of those forms from *any* (not all) other of the Ganoids, and consequently evidence *ubi plurima nitent* against the taxonomic value of the characters employed for distinction.

"And it is true that there is a greater superficial resemblance between the Hyoganoids (*Lepisosteus*, *Amia*, etc.) and ordinary physostome Teleosts than between the former and the other orders of Ganoids, but it is equally true that they agree in other respects than in the brain and heart with the more generalized

Ganoids. They all have, for example, (1) the paraglenal elements undivided (not disintegrated into hypercoracoid, hypocoracoid, and mesocoracoid; (2) a humerus (simple or divided, that is, differentiated into metapterygium and mesopterygium); and (3) those with ossified skeletons agree in the greater number of elements in the lower jaw. Therefore, until these coordinates fail, it seems advisable to recognize the Ganoids as constituents of a natural series; and especially on account of the superior taxonomic value of modifications of the brain and heart in other classes of vertebrates, for the same reason, and to keep prominently before the mind the characters in question, it appears also advisable to designate the series, until further discovery, as a subclass.

"But it is quite possible that among some of the generalized Teleosts at least *traces* of some of the characters now considered to be peculiar to the Ganoids may be discovered. In anticipation of such a possibility, the author had at first discarded the subclass, recognizing the group only as one of the 'superorders' of the Teleostomes, but reconsideration convinces him of the propriety of classification representing known facts and legitimate inferences rather than too much anticipation.

"It is remembered that all characters are liable to fail with increasing knowledge, and the distinctness of groups are but little more than the expressions of our want of knowledge of the intermediate forms; it may in truth be said that ability to segregate a class into well-defined groups is in ratio to our ignorance of all the terms."

CHAPTER II

THE GANOIDS—Continued

CLASSIFICATION of Ganoids. — The subdivision of the series of Ganoidei into orders offers great difficulty from the fact of the varying relationships of the members of the group and the fact that the great majority of the species are known only from broken skeletons preserved in the rocks. It is apparently easy to separate those with cartilaginous skeletons from those with these bones more or less ossified. It is also easy to separate those with bony scales or plates from those having the scales cycloid. But the one type of skeleton grades into the other, and there is a bony basis even to the thinnest of scales found in this group. Among the multitude of names and divisions proposed we may recognize six orders, for which the names *Lysopteri*, *Chondrostei*, *Selachostomi*, *Pycnodonti*, *Lepidostei*, and *Halecomorphi* are not inappropriate. Each of these seems to represent a distinct offshoot from the first primitive group.

Order Lysopteri.—In the most primitive order, called *Lysopteri* (λυσός, loose; πτερόν, fin) by Cope, *Heterocerci* by Zittel and Eastman, and the "ascending series of Chondrostei" by Woodward, we find the nearest approach to the Chondropterygians. In this order the arches of the vertebræ are more or less ossified, the body is more or less short and deep, covered with bony dermal plates. The opercular apparatus is well developed, with numerous branchiostegals. Infraclavicles are present, and the fins provided with fulcra. Dorsal and anal fins are present, with rays more numerous than their supports; ventral fin with basal supports which are imperfectly ossified; caudal fin mostly heterocercal, the scales mostly rhombic in form. All the members of this group are now extinct.

The Palæoniscidæ.—The numerous genera of this order are referred to three families, the *Palæoniscidæ*, *Platysomidæ*, and *Dictyopygidæ*; a fourth family, *Dorypteridæ*, of uncertain relations, being also tentatively recognized. The family of *Palæoniscidæ* is the most primitive, ranging from the Devonian to the Lias, and some of them seem to have entered fresh waters in the time of the coal-measures. These fishes have the body elongate and provided with one short dorsal fin. The tail is hetercoercal and the body covered with rhombic plates. Fulcra or rudimentary spine-like scales are developed on the upper edge of the caudal fin in most recent Ganoids, and often the back has a median row of undeveloped scales. A multitude of species and genera are recorded A typical form is the genus *Palæoniscum*,* with many species represented in the rocks of various parts of the world. The longest known species is *Palæoniscum frieslebenense* from the Permian of Germany and England. *Palæoniscum magnum*, sixteen inches long, occurs

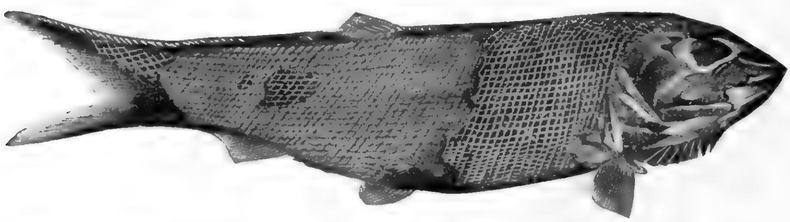


FIG. 2.—*Palæoniscum frieslebenense* Blainville. Family *Palæoniscidæ*. (After Zittel.)

in the Permian of Germany. From *Canobius*, the most primitive genus, to *Coccolepis*, the most modern, is a continuous series, the suspensorium of the lower jaw becoming more oblique, the basal bones of the dorsal fewer, the dorsal extending farther forward, and the scales more completely imbricate. Other prominent genera are *Amblypterus*, *Eurylepis*, *Cheirolepis*, *Rhadinichthys*, *Pygopterus*, *Elonichthys*, *Ærolepis*, *Gyrolepis*, *Myriolepis*, *Oxygnathus*, *Centrolepis*, and *Holurus*.

The Platysomidæ. — The *Platysomidæ* are different in form, the body being deep and compressed, often diamond-shaped,

* This word is usually written *Palæoniscus*, but Blainville, its author (1818), chose the neuter form.

with very long dorsal and anal fins. In other respects they are very similar to the *Palæoniscidæ*, the osteology being the same. The *Palæoniscidæ* were rapacious fishes with sharp teeth, the *Platysomidæ* less active, and, from the blunter teeth, probably feeding on small animals, as crabs and snails.

The rhombic enameled scales are highly specialized and held together as a coat of mail by peg-and-socket joints. The most extreme form is *Platysomus*, with the body very deep. *Platysomus gibbosus* and other species occur in the Permian rocks of Germany. *Cheirodus* is similar to *Platysomus*, but without ventral fins. *Eurynotus*, the most primitive genus, is remarkable for its large pectoral fins. *Eurynotus crenatus* occurs

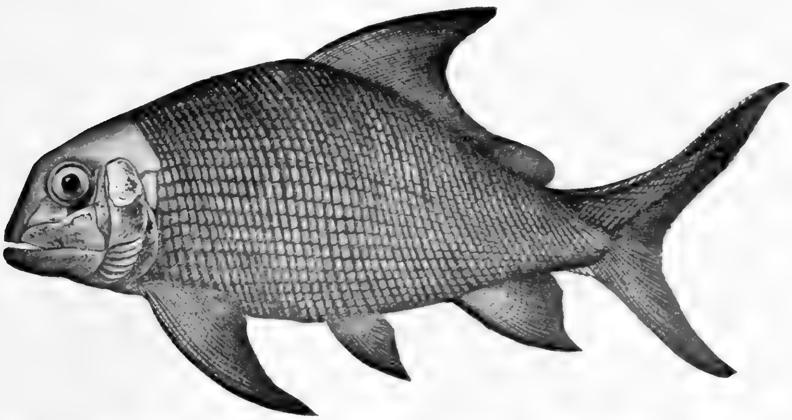


FIG. 3.—*Eurynotus crenatus* Agassiz, restored. Carboniferous. Family *Platysomidæ*. (After Traquair.)

in the Subcarboniferous of Scotland. Other genera are *Mesolepis*, *Globulodus*, *Wardichthys*, and *Cheirodopsis*.

Some of the *Platysomidæ* have the interneural spines projecting through the skin before the dorsal fin. This condition is found also in certain bony fishes allied to the *Carangidæ*.

The Dorypteridæ.—*Dorypterus hoffmani*, the type of the singular Palæozoic family of *Dorypteridæ*, with thoracic or subjugular many-rayed ventrals, is Stromateus-like to all appearance, with distinct resemblances to certain Scombroid forms, but with a heterocercal tail like a ganoid, imperfectly ossified back-bone, and other very archaic characters. The body is apparently scaleless, unlike the true *Platysomidæ*, in which the

scales are highly developed. A second species, *Dorypterus althausi*, also from the German copper shales, has been described. This species has lower fins than *Dorypterus hoffmani*, but may be the adult of the same type. *Dorypterus* is regarded by Woodward as a specialized offshoot from the *Platysomidæ*. The many-rayed ventrals and the general form of the body and fins suggest affinity with the *Lampridæ*.

Dictyopygidæ.—In the *Dictyopygidæ* (*Catopteridæ*), the body is gracefully elongate, less compressed, the heterocercal tail is short and abruptly turned upwards, the teeth are sharp and usually hooked, and the bony plates well developed. Of this group two genera are recognized, each containing numerous species. In *Redfieldius* (=*Catopterus* Redfield, not of Agassiz) the dorsal is inserted

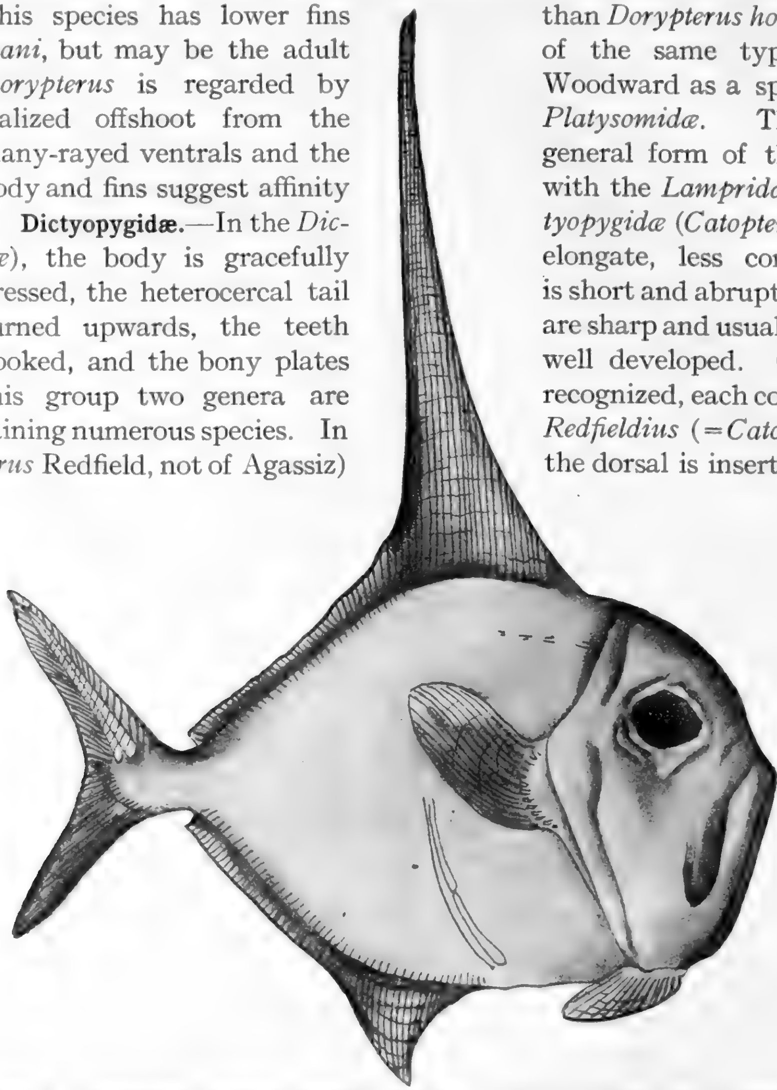


FIG. 4.—*Dorypterus hoffmani* Germar, restored. (After Hancock and Howse.)

behind the anal, while in *Dictyopyge* this is not the case. *Redfieldius gracilis* and other species are found in the Triassic of the Connecticut River. *Dictyopyge macrura* is found in the same region, and *Dictyopyge catoptera* and other species in Europe.

Order Chondrostei.—The order *Chondrostei* (χόνδρος, cartilage; ὀστέον, bone), as accepted by Woodward, is characterized by the persistence of the notochord in greater or less degree, the endoskeleton remaining cartilaginous. In all, the axonosts and baseosts of the median fins are arranged in simple regular series and the rays are more numerous than the supporting elements. The shoulder-girdle has a pair of infraclavicular plates. The pelvic fins have well-developed baseosts. The branchiostegals are few or wanting. In the living forms, and probably in all others, a matter which can never be ascertained, the optic nerves are not decussating, but form an optic chiasma, and the intestine is provided with a spiral valve. In all the species there is one dorsal and one anal fin, separate from the caudal. The teeth are small or wanting, the body naked or covered with bony plates; the caudal fin is usually heterocercal, and on the tail are rhombic plates. To this order, as thus defined, about half of the extinct Ganoids belong, as well as the modern degenerate forms known as sturgeons and perhaps the paddle-fishes, which are apparently derived from fishes with rhombic enameled scales. The species extend from the Upper Carboniferous to the present time, being most numerous in the Triassic.

At this point in Woodward's system diverges a descending series, characterized as a whole by imperfect squamation and elongate form, this leading through the synthetic type of *Chondrosteidæ* to the modern sturgeon and paddle-fish, which are regarded as degenerate types.

The family of *Saurorhynchidæ* contains pike-like forms, with long jaws, and long conical teeth set wide apart. The tail is not heterocercal, but short-diphycercal; the bones of the head are covered with enamel, and those of the roof of the skull form a continuous shield. The opercular apparatus is much reduced, and there are no branchiostegals. The fins are all small, without fulcra, and the skin has isolated longitudinal series of bony scutes, but is not covered with continuous scales. The principal genus is *Saurorhynchus* (=*Belonorhynchus*; the former being the earlier name) from the Triassic. *Saurorhynchus acutus* from the English Triassic is the best known species.

The family of *Chondrosteidæ* includes the Triassic precursors

of the sturgeons. The general form is that of the sturgeon, but the body is scaleless except on the upper caudal lobe, and there are no plates on the median line of the skull. The opercle and subopercle are present, the jaws are toothless, and there are a few well-developed caudal rays. The caudal has large fulcra. The single well-known species of this group, *Chondrosteus acipenseroides*, is found in the Triassic rocks of England and reaches a length of about three feet. It much resembles a modern sturgeon, though differing in several technical respects. *Chondrosteus pachyurus* is based on the tail of a species of much larger size and *Gyrosteus mirabilis*, also of the English Triassic,

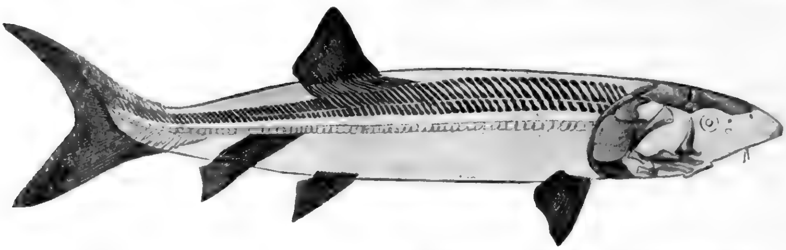


Fig. 5.—*Chondrosteus acipenseroides* Egerton. Family *Chondrosteidæ*. (After Woodward.)

is known from fragments of fishes which must have been 18 to 20 feet in length.

The sturgeons constitute the recent family of *Acipenseridæ*, characterized by the prolonged snout and toothless jaws and the presence of four barbels below the snout. In the *Acipenseridæ* there are no branchiostegals and a median series of plates is present on the head. The body is armed with five rows of large bony bucklers,—each often with a hooked spine, sharpest in the young. Besides these, rhombic plates are developed on the tail, besides large fulcra. The sturgeons are the youngest of the Ganoids, not occurring before the Lower Eocene, one species, *Acipenser toliapicus* occurring in the London clay. About thirty living species of sturgeon are known, referred to three genera: *Acipenser*, found throughout the Northern Hemisphere, *Scaphirhynchus*, in the Mississippi Valley, and *Kessleria* (later called *Pseudoscaphirhynchus*), in Central Asia alone. Most of the species belong to the genus *Acipenser*, which abounds in all the rivers and seas in which salmon are found. Some of the smaller species spend their lives in the rivers, ascend-

ing smaller streams to spawn. Other sturgeons are marine, ascending fresh waters only for a moderate distance in the spawning season. They range in length from $2\frac{1}{2}$ to 30 feet.

All are used as food, although the flesh is rather coarse and beefy. From their large size and abundance they possess great economic value. The eggs of some species are prepared as caviar.

The sturgeons are sluggish, clumsy, bottom-feeding fish. The mouth, underneath the long snout, is very protractile, sucker-like, and without teeth. Before it on the under side of the snout are four long feelers. Ordinarily the sturgeon feeds on mud and snails with other small creatures, but I have seen

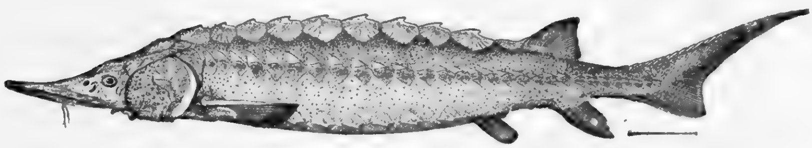


Fig. 6.—Common Sturgeon, *Acipenser sturio* Mitchill. Potomac River.

large numbers of Eulachon (*Thaleichthys*) in the stomach of the Columbia River sturgeon (*Acipenser transmontanus*). This fish and the Eulachon run in the Columbia at the same time, and the sucker-mouth of a large sturgeon will draw into it numbers of small fishes who may be unsuspiciously engaged in depositing their spawn. In the spawning season in June these clumsy fishes will often leap wholly out of the water in their play. The sturgeons have a rough skin besides five series of bony plates which change much with age and which in very old examples are sometimes lost or absorbed in the skin. The common sturgeon of the Atlantic on both shores is *Acipenser sturio*. *Acipenser huso* and numerous other species are found in Russia and Siberia. The great sturgeon of the Columbia is *Acipenser transmontanus*, and the great sturgeon of Japan *Acipenser kikuchii*. Smaller species are found farther south, as in the Mediterranean and along the the Carolina coast. Other small species abound in rivers and lakes. *Acipenser rubicundus* is found throughout the Great Lake region and the Mississippi Valley, never entering the sea. It is four to six feet long, and at Sandusky, Ohio, in one season 14,000 sturgeons were taken

in the pound nets. A similar species, *Acipenser mikadoi*, is abundant and valuable in the streams of northern Japan.

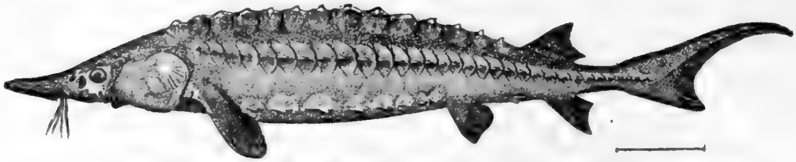


FIG. 7.—Lake Sturgeon, *Acipenser rubicundus* Le Sueur. Ecorse, Mich.

In the genus *Acipenser* the snout is sharp and conical, and the shark-like spiracle is still retained.

The shovel-nosed sturgeon (*Scaphirhynchus platyrhynchus*) has lost the spiracles, the tail is more slender, its surface wholly bony, and the snout is broad and shaped like a shovel. The single species of *Scaphirhynchus* abounds in the Mississippi

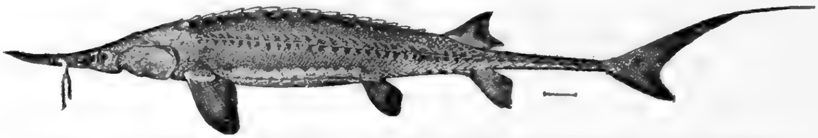


FIG. 8.—Shovel-nosed Sturgeon. *Scaphirhynchus platyrhynchus* (Rafinesque). Ohio River.

Valley, a fish more interesting to the naturalist than to the fisherman. It is the smallest of our sturgeons, often taken in the nets in large numbers.

In *Scaphyrhynchus* the tail is covered by a continuous coat of mail. In *Kessleria* * *fedtschenkoi*, *rossikowi*, and other Asiatic species the tail is not mailed.

Order Selachostomi: the Paddle-fishes. — Another type of Ganoids, allied to the sturgeons, perhaps still further degenerate, is that of the paddle-fishes, called by Cope *Selachostomi* (σέλαχος, shark; στόμα, mouth). This group consists of a single family, *Polyodontidæ*, having apparently little in common with the other Ganoids, and in appearance still more suggestive of the sharks. The common name of paddle-fishes is derived from the long flat blade in which the snout terminates. This extends far beyond the mouth, is more or less sensitive, and is

* These species have also been named *Pseudoscaphirhynchus*. *Kessleria* is the earlier name, left undefined by its describer, although the type was indicated.

used to stir up the mud in which are found the minute organisms on which the fish feeds. Under the paddle are four very minute

Fig. 9.—Paddle-fish, *Polyodon spathula* (Walbaum). Ohio River.

barbels corresponding to those of the sturgeons. The vernacular names of spoonbill, duckbill cat, and shovel-fish are also derived from the form of the snout. The skin is nearly smooth, the tail is heterocercal, the teeth are very small, and a long fleshy flap covers the gill-opening. The very long and slender gill-rakers

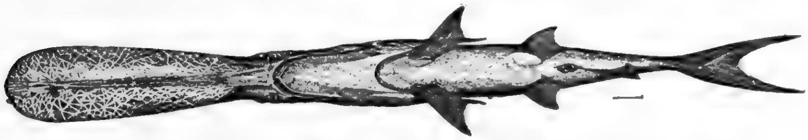


Fig. 10.—Paddle-fish, *Polyodon spathula* (Walbaum). Ohio River.

serve to strain the food (worms, leeches, water-beetles, crustaceans, and algæ) from the muddy waters from which they are taken. The most important part of this diet consists of Entomostracans. The single American species, *Polyodon spathula*, abounds through the Mississippi Valley in all the larger streams. It reaches a length of three or four feet. It is often taken in the nets, but the coarse tough flesh, like that of our inferior catfish, is not much esteemed. In the great rivers of China, the Yangtse and the Hoang Ho, is a second species,

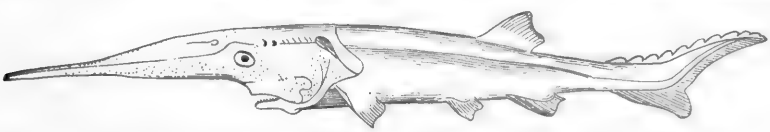


Fig. 11.—*Psephurus gladius* Günther. Yangtse River. (After Günther.)

Psephurus gladius, with narrower snout, fewer gill-rakers, and much coarser fulcra on the tail. The habits, so far as known, are much the same.

Crossopholis magnicaudatus of the Green River Eocene shales is a primitive member of the *Polyodontidæ*. Its rostral blade

is shorter than that of *Polyodon*, and the body is covered with small thin scales, each in the form of a small grooved disk with several posterior denticulations, arranged in oblique series but not in contact. The scales are quadrate in form, and more widely separated anteriorly than posteriorly. As in *Polyodon*, the teeth are minute and there are no branchiostegals. The squamation of this fish shows that *Polyodon* as well as *Acipenser* may have sprung from a type having rhombic scales. The tail of a Cretaceous fish, *Pholidurus disjectus* from the Cretaceous of Europe, has been referred with doubt to this family of *Polyodontidæ*.

Order Pycnodonti.—In the extinct order *Pycnodonti*, as recognized by Dr. O. P. Hay, the notochord is persistent and without ossification, the body is very deep, the teeth are always

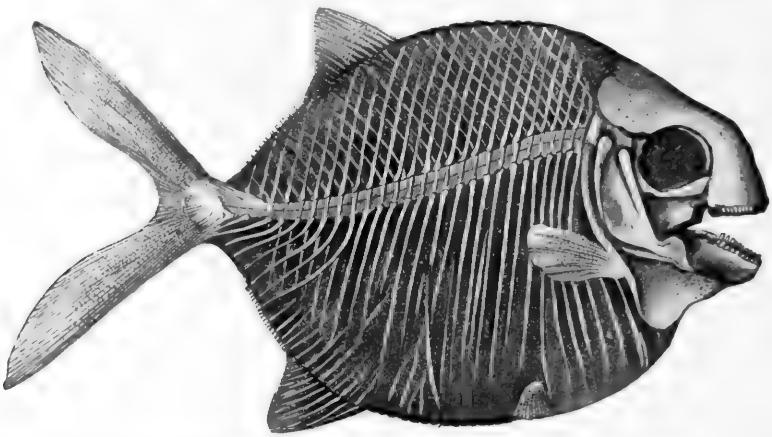


Fig. 12.—*Gyrodus hexagonus* Agassiz. Family *Pycnodontidæ*. Lithographic Shales.

blunt, the opercular apparatus is reduced, the dorsal fin many-rayed, and the fins without fulcra. The scales are rhombic, but are sometimes wanting, at least on the tail. Many genera and species of *Pycnodontidæ* are described, mostly from Triassic and Jurassic rocks of Europe. Leading European genera are *Pycnodus*, *Typodus* (*Mesodon*), *Gyrodus*, and *Palæobalistum*. The numerous American species belong to *Typodus*, *Cœlodus*, *Pycnodus*, *Hadrodus*, and *Uranoplosus*. These forms have no affinity with *Balistes*, although there is some resemblance in appearance, which has suggested the name of *Palæobalistum*.

Woodward places these fishes with the *Semionotidæ* and *Halecomorphi* in his suborder of *Protospondyli*. It seems preferable, however, to consider them as forming a distinct order.

Order Lepidostei.—We may place, following Eastman's edition of Zittel, the allies and predecessors of the garpike in a single order, for which Huxley's name *Lepidostei* may well be used. In this group the notochord is persistent, and the vertebræ are in various degrees of ossification and of different forms. The

FIG. 13.—*Mesturus verrucosus* Wagner. Family *Pycnodontidæ*. (After Woodward.)

opercles are usually complete, the branchiostegals present, and there is often a gular plate. There is no infraclavicle and the jaws have sharp teeth. The fins have fulcra, and the supports of the fins agree in number with the rays. The tail is more or less heterocercal. The scales are rhombic, arranged in oblique series, which are often united above and below with peg-and-socket articulations. This group contains among recent fishes only the garpikes (*Lepisosteus*). They are closely allied to the *Palæoniscidæ*, but the skeleton is more highly ossified. On the other hand they approach very closely to the ancestors of the bowfin, *Amia*. One genus, *Acentrophorus*, appears in the Permian; the others are scattered through Mesozoic and Tertiary rocks, the isolated group of gars still persisting. In the gars the vertebræ are concavo-convex, with ball-and-socket joints. In the others the vertebræ are incomplete or else double-concave, as in fishes generally.

For the group here called *Lepidostei* numerous other names have been used corresponding wholly or in part. *Rhomboganoidea* of Gill covers nearly the same groups; *Holostei* of Müller and *Hyoganoidea* of Gill include the *Halecomorphi* also; *Ginglymodi* of Cope includes the garpikes only, while *Ætheospondyli* of Woodward includes the *Aspidorhynchidæ* and the garpikes.

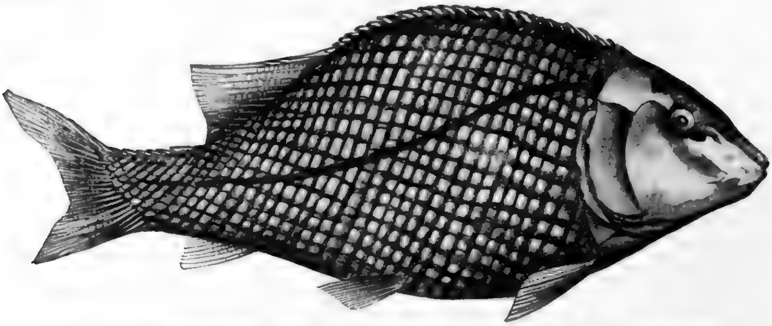


FIG. 14.—*Semionotus kapffi* Fraas, restored. Family *Semionotidæ*. (After Fraas, per Nicholson.)

The *Semionotidæ* (*Stylodontidæ*) are robust-bodied Ganoids, having the vertebræ developed as rings, the jaws with several rows of teeth, those of the outer row styliform.

Semionotus bergeri is a well-known species, with the body moderately elongate. *Semionotus agassizi* and many other species occur in the Triassic of the Connecticut valley and in New Jersey. The body is very deep in the related genus *Dapedium*, and the head is covered with strong bony plates. *Dapedium politum* is a well-known species of the English Triassic. *Tetragonolepis* (*Pleurolepis*) is a similar form, very deep and compressed, with strong, firm scales.

In the extinct family of *Lepidotidæ* the teeth are conical or chisel-shaped, while blunt or molar teeth are on the inside of the mouth, which is small, and the suspensorium of the mandible is vertical or inclined forward. The body is robust-fusiform, covered with rhomboid scales; the vertebræ form rings about the notochord; the teeth are either sharp or blunt. The dorsal fin is short, with large fulcra.

The best known of the numerous genera are *Lepidotes*, rather elongate in body, with large, blunt teeth. Of the many species of *Lepidotes*, *Lepidotes elvensis* abounds in the English

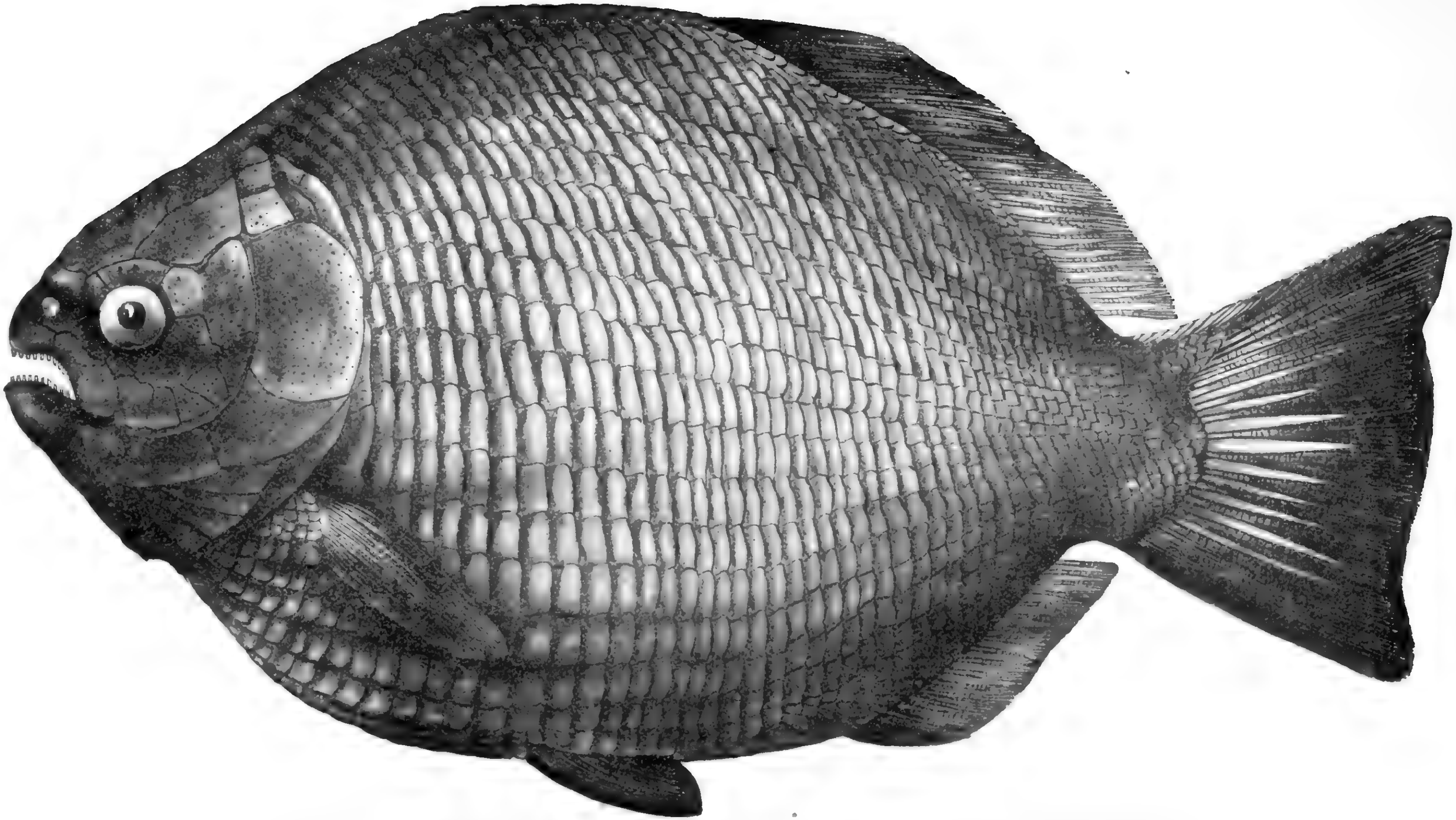


FIG. 15.—*Dapedium politum* Leach, restored. Family *Semionotidæ*. (After Woodward.)

and German Triassic, and *Lepidotes minor* in the English Triassic. Another well-known European species is *Lepidotes mantelli*.

The *Isopholidæ* (*Eugnathidæ*) differ from the families last named in the large pike-like mouth with strong teeth. The mandibular suspensorium is inclined backwards. The body is elongate, the vertebræ forming incomplete rings; the dorsal fin is short with large fulcra.

Isopholis dentosus is found with numerous other species in the British Triassic. *Caturus furcatus* is especially characteristic

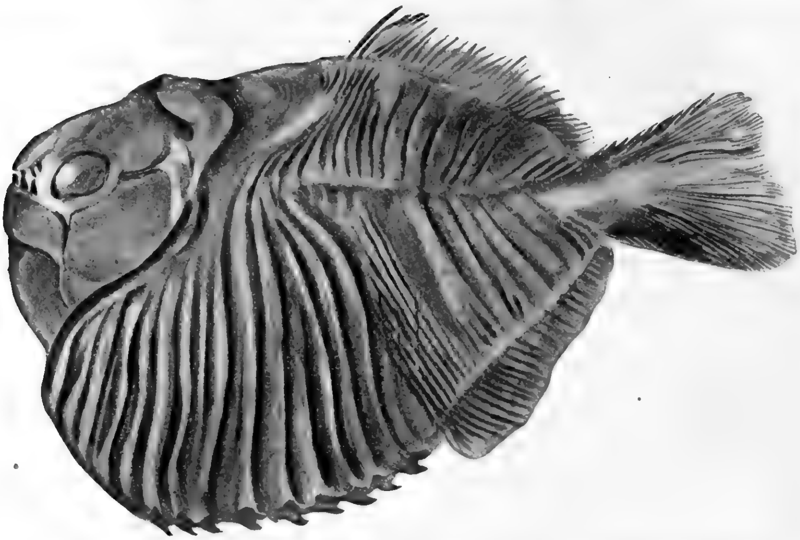


FIG. 16.—*Tetragonolepis semicinctus* Brown. Lias. Family *Semionotidæ*. (After Woodward.)

of Triassic rocks in Germany. *Ptycholepis marshi* occurs in the Connecticut valley.

The *Macrosemiidæ* are elongate fishes with long dorsal fin, the numerous species being found in the Triassic, Jurassic, and Cretaceous of Europe. *Macrosemius rostratus* has a very high, continuous dorsal. *Macropistius arenatus* is found in the Cretaceous of Texas, the only American species known. Prominent European genera are *Notagogus*, *Ophiopsis*, and *Petalopteryx*.

Intermediate between the allies of the gars and the modern herrings is the large extinct family of *Pholidophoridæ*, referred by Woodward to the *Isospondyli*, and by Eastman to the *Lepidostei*. These are small fishes, fusiform in shape, chiefly of

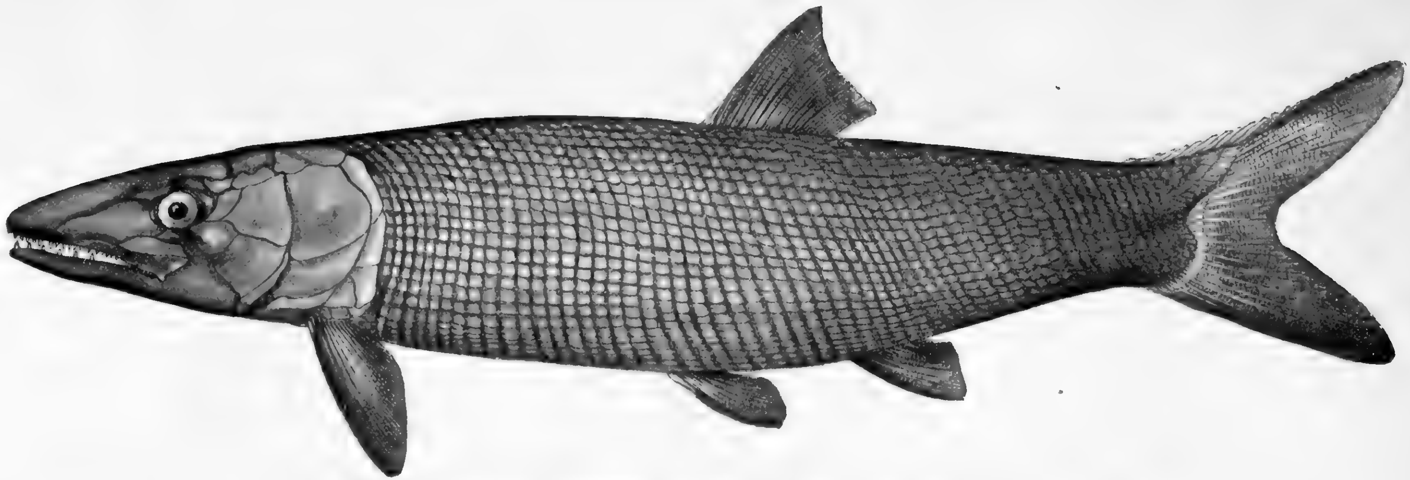


Fig. 17.—*Isopholis orthostomus* (Agassiz). Lias. (After Woodward.)

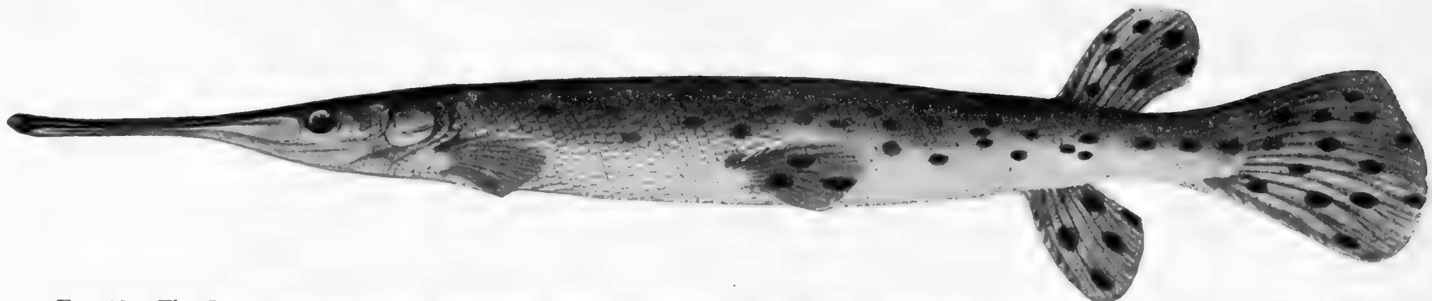


Fig. 18.—The Long-nosed Garpike, *Lepisosteus osseus* (Linnæus). Fox River, Wisconsin. (From nature; D. S. Jordan and M. L. McDonald, 1874.)

the Triassic and Jurassic. The fins are fringed with fulcra, the scales are ganoid and rhombic, and the vertebræ reduced

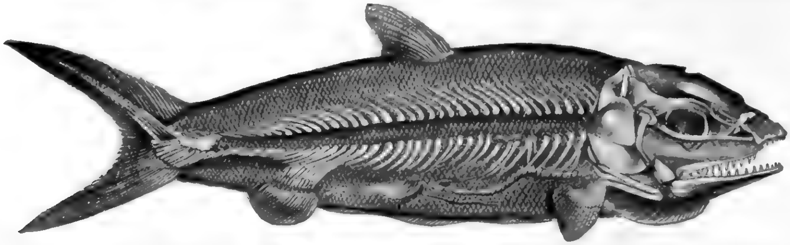


Fig. 19.—*Caturus elongatus* Agassiz. Jurassic. Family *Isopholidæ*. (After Zittel.)

to rings. The mouth is large, with small teeth, and formed as in the *Isospondyli*. The caudal is scarcely heterocercal.

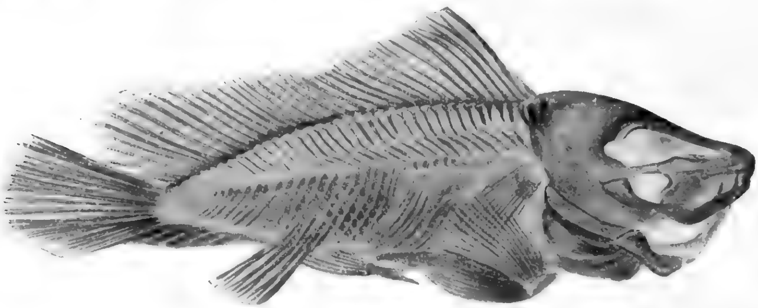


Fig. 20.—*Notagogus pentlandi* Agassiz. Jurassic. Family *Macrosemiidæ*. (After Woodward.)

Of *Pholidophorus*, with scales joined by peg-and-socket joints and uniform in size, there are many species. *Pholidophorus*

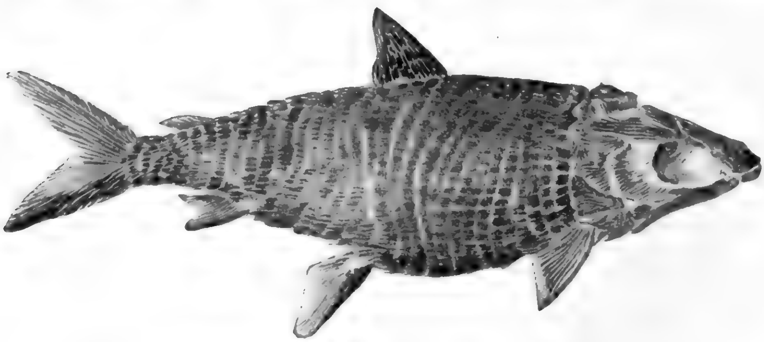


Fig. 21.—*Ptycholepis curtus* Egerton. Lias. Family *Isopholidæ*. (After Woodward.)

latiusculus and many others are found in the Triassic of England and the Continent. *Pholidophorus americanus* occurs in the

Jurassic of South Dakota. *Pleuropholis*, with the scales on the lateral line, which runs very low, excessively deepened, is also widely distributed. I have before me a new species from the Cretaceous rocks near Los Angeles. The *Archæomænidæ* differ from *Pholidophoridæ* in having cycloid scales. In both families the vertebræ are reduced to rings about the notochord. From fishes allied to the *Pholidophoridæ* the earliest *Isospondyli* are probably descended.

In the *Aspidorhynchidæ* the snout is more or less produced, the mandible has a distinct presymphysial bone, the vertebræ are double-concave or ring-like, and the fins are without fulcra. This family constitutes the suborder *Ætheospondyli*. In form these fishes resemble *Albula* and other modern types, but have

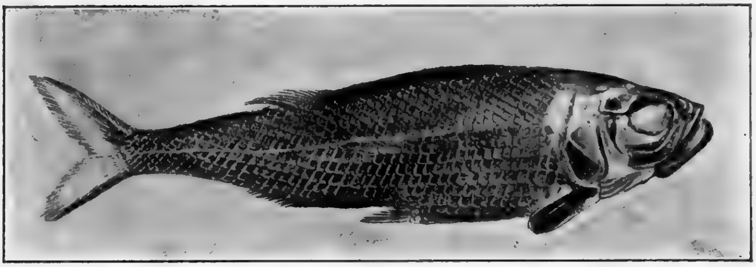


Fig. 22.—*Pholidophorus crenulatus* Egerton. Lias. (After Woodward.)

mailed heads and an ancient type of scales. Two genera are well known, *Aspidorhynchus* and *Belonostomus*. *Aspidorhynchus acutirostris* reaches a length of three feet, and is found in the Triassic lithographic stone of Bavaria. Other species occur in rocks of Germany and England.

Belonostomus has the snout scarcely produced. *Belonostomus sphyrænoides* is the best known of the numerous species, all of the Triassic, Jurassic, and Cretaceous.

Family Lepisosteidæ.—The family of *Lepisosteidæ*, constituting the suborder *Ginglymodi* (γιγγλυμός, hinge), is characterized especially by the form of the vertebræ.

These are opisthocœlian, convex in front and concave behind, as in reptiles, being connected by ball-and-socket joints. The tail is moderately heterocercal, less so than in the *Halecomorphi*, and the body is covered with very hard, diamond-shaped, enameled

scales in structure similar to that of the teeth. A number of peculiar characters are shown by these fishes, some of them having often been regarded as reptilian traits. Notable features are the elongate, crocodile-like jaws, the upper the longer, and both armed with strong teeth. The mandible is without pre-symphysial bone. The fins are small with large fulcra, and the scales are nearly uniform in size.

All the species belong to a single family, *Lepisosteidæ*, which includes the modern garpikes and their immediate relatives, some of which occur in the early Tertiary. These voracious fishes are characterized by long and slender cylindrical bodies, with enameled scales and mailed heads and heterocercal tail. The teeth are sharp and unequal. The skeleton is well ossified, and the animal itself is extremely voracious. The vertebræ, reptile-like, are opisthocœlian, that is, convex in front, concave behind, forming ball-and-socket joints. In almost all other fishes they are amphicœlian or double-concave, the interspace filled with gelatinous substance. The recent species, and perhaps all the extinct species also, belong to the single genus *Lepisosteus* (more correctly, but also more recently, spelled *Lepidosteus*). Of existing forms there are not many species, three to five at the most, and they swarm in the lakes, bayous, and sluggish streams from Lake Champlain to Cuba and along the coast to Central America. The best known of the species is the long-nosed garpike, *Lepisosteus osseus*, which is found throughout most of the Great Lake region and the Mississippi Valley, and in which the long and slender jaws are much longer than the rest of the head. The garpike frequents quiet waters and is apparently of sleepy habit. It often lies quiet for a long time, carried around and around by the eddies. It does not readily take the hook and seldom feeds in the aquarium. It feeds on crayfishes and small fishes, to which it is exceedingly destructive, as its bad reputation indicates. Fishermen everywhere destroy it without mercy. Its flesh is rank and tough and unfit even for dogs.

In the young garpike the caudal fin appears as a second dorsal and anal, the filamentous tip of the tail passing through and beyond it.

The short-nosed garpike, *Lepisosteus platystomus*, is gener-

ally common throughout the Mississippi Valley. It has a short broad snout like the alligator gar, but seldom exceeds three feet in length. In size, color, and habits it agrees closely with the common gar, differing only in the form of the snout. The form is subject to much variation, and it is possible that two or more species have been confounded.

The great alligator-gar, *Lepisosteus tristœchus*, reaches a length of twenty feet or more, and is a notable inhabitant of the streams about the Gulf of Mexico. Its snout is broad and relatively wide, and its teeth are very strong. It is very destructive to all sorts of food-fishes. Its flesh is worthless, and its enameled scales resist a spear or sometimes even shot.

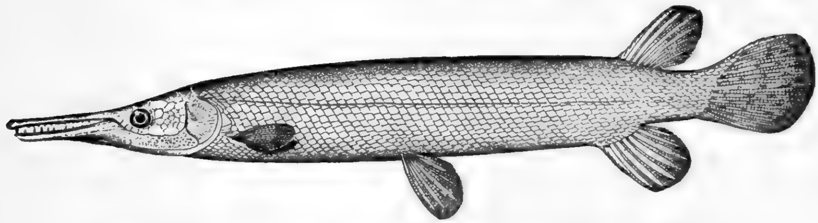


FIG. 23.—Alligator-gar, *Lepisosteus tristœchus* (Bloch). Cuba.

It breathes air to a certain extent by its lungs, but soon dies in foul water, not having the tenacity of life seen in *Amia*.

Embryology of the Garpike. — Mr. Alexander Agassiz has given an account of the embryology of the garpike, of which the following is an abstract:

"The garpike comes up the St. Lawrence in May, lays its eggs about the 20th, and then disappears. The eggs are large, viscous, stick fast in an isolated way to whatever they fall upon, and look much like those of toads, having a large outer membrane and a small yolk. Artificial fecundation failed, but about 500 naturally-laid eggs were secured, of which all but 30 perished through mold. The young began to hatch in six days. Out of 30 young hatched, 27 lived until the 15th of July. Connection with the sharks appears in the similarity of the branchial arches and by the presence of the lateral fold in which the pectoral fins are formed; the way the tail is developed is very like that of the bony fishes. Among the Ganoids it appears, as well as in ordinary fishes, the dorsal cord is straight at first, then assumes a slightly up-

ward curve at the extremity, when finally there appears the beginning of a lobe underneath, pointing to a complete heterocercal tail. All this is as in the bony fishes, but this is the permanent condition of the garpike, while in the bony fishes the extremity of the dorsal cord becomes extinct. The mode of development of the pectoral lobe (very large in this species) furnishes another resemblance. In the brain, and in the mode of formation of the gills, a likeness to the sharks is noticeable. The young garpikes move very slowly, and seem to float quietly, save an exceedingly rapid vibration of the pectorals and the tip of the tail. They do not swim about much, but attach themselves to fixed objects by an extraordinary horseshoe-shaped ring of sucker-appendages about the mouth. These appendages remain even after the snout has become so extended that the ultimate shape is hinted at; and furthermore, it is a remnant of this feature that forms the fleshy bulb at the end of the snout in the adult. The investigations thus far show that the young garpike has many characteristics in common with the sharks and skates, but it is not so different from the bony fishes as has been supposed."

Fossil Garpikes.—A number of fossil garpikes, referred by Cope to the genus *Clastes* and by Eastman and Woodward to *Lepidosteus*, are found in the Eocene of Europe and America. The most perfect of these remains is called *Lepisosteus atrox*, upward of four feet long, as large as an alligator-gar, which the species much resembles. Although found in the Eocene, Dr. C. R. Eastman declares that "it has no positively archaic features. If we inquire into the more remote or pre-Eocene history of Lepidosteids, palæontology gives no answer. They blossom forth suddenly and fully differentiated at the dawn of the Tertiary, without the least clue to their ancestry, unheralded and unaccompanied by any intermediate forms, and they have remained essentially unchanged ever since."

Another fossil species is *Lepisosteus fimbriatus*, from the Upper Eocene of England. Scales and other fragments of garpikes are found in Germany, Belgium, and France, in Eocene and Miocene rocks. On some of these the nominal genera *Naisia*, *Trichiurides*, and *Pneumatosteus* are founded. *Clastes*, regarded by Eastman as fully identical with *Lepisosteus*, is said

to have the "mandibular ramus without or with a reduced fissure of the dental foramen, and without the groove continuous with it in *Lepisosteus*. One series of large teeth, with small ones external to them on the dentary bone." Most of the fossil forms belong to *Clastes*, but the genus shows no difference of importance which will distinguish it from the ordinary garpike.

Order Halecomorphi.—To this order belong the allies, living or extinct, of the bowfin (*Amia*), having for the most part cycloid scales and vertebræ approaching those of ordinary

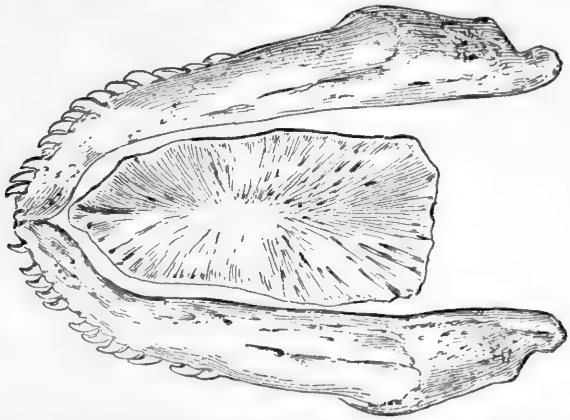


FIG. 24.—Lower jaw of *Amia calva* Linnæus, showing the gular plate.

fishes. The resemblance to the *Isospondyli*, or herring group, is indicated in the name (Halec, a herring; μορφή, form). The notochord is persistent, the vertebræ variously ossified. The opercles are always complete. The branchiostegals are broad and there is always a gular plate. The teeth are pointed, usually strong. There is no infraclavicle. Fulcra are present or absent. The supports of the dorsal and anal are equal in number to the rays. Tail heterocercal. Scales thin, mostly cycloid, but bony at base, not jointed with each other. Mandible complex, with well-developed splenial rising into a coronoid process, which is completed by a distinct coronoid bone. Pectoral fin with more than five actinosts; scales ganoid or cycloid. In the living forms the air-bladder is connected with the œsophagus through life; optic chiasma present; intestine with a spiral valve. This group corresponds to the *Amioidei* of Lütken

and essentially to the *Cycloganoidei* of Gill. The *Protospondyli* (*προτός*, before; *σπόνδυλος*, vertebra) of Woodward contains essentially the same elements.

Pachycormidæ.—In the family of *Pachycormidæ* the notochord is persistent, the ethmoids and vomer fused and projecting between the maxillaries to form the prominent snout, the teeth large, the body fusiform, the dorsal short, with slender rays and few fulcra or none, and the scales are thin and rhombic. The numerous species are characteristic of the Triassic, Jurassic, and Cretaceous. In *Sauropsis* (*longimana*) the body is elongate, and the pectoral fins are large and sickle-shaped. *Euthynotus* has small fulcra. In *Pachycormus* (*macropterus*, *esocinus*, etc.) the form is robust and the ventral fins are wanting. In *Hypsycormus* ventrals are present, and the caudal deeply forked.

In the American family of *Protosphyrænidæ* the jaws are armed with very strong teeth, as in the Barracuda, which, however, the species do not resemble in other respects. *Protosphyræna nitida*, *perniciosa*, and numerous other extinct forms, some of them of large size, were voracious inhabitants of the Cretaceous seas, and are found fossil, especially in North Carolina and Kansas. Numerous species called *Erisichthe* and *Pelecopterus* are all referred by Hay to *Protosphyræna*. In this family the scapula and coracoids are ossified, and perhaps the vertebræ also, and, as Dr. Hay has recently suggested, the *Protosphyrænidæ* may really belong to the *Isospondyli*. In any event, they stand on the border-line between the most fish-like of the Ganoids and the most archaic of the bony fishes.

The *Liodesmidæ* (genus *Liodesmus*) are much like *Amia*, but the notochord is persistent, its sheath without ossification. *Liodesmus gracilis* and *L. sprattiformis* occur in the lithographic stones of Bavaria. Woodward places *Liodesmus* with *Megalurus* among the *Amiidæ*.

The Bowfins: Amiidæ.—The *Amiidæ* have the vertebræ more complete. The dorsal fin is many-rayed and is without distinct fulcra. The diamond-shaped enameled scales disappear, giving place to cycloid scales, which gradually become thin and membranous in structure. A median gular plate is developed between the branchiostegals. The tail is moderately heterocercal, and the head covered with a bony coat of mail.

The family of *Amiidæ* contains a single recent species, *Amia calva*, the only living member of the order *Halecomorphi*. The bowfin, or grindle, is a remarkable fish abounding in the lakes and swamps of the Mississippi Valley, the Great Lake region, and southward to Virginia, where it is known by the imposing but unexplained title of John A. Grindle. In the Great Lakes it is usually called "dogfish," because even the dogs will not eat it, and "lawyer," because, according to Dr. Kirtland, "it will bite at anything and is good for nothing when caught."

The bowfin reaches a length of two and one half feet, the male being smaller than the female and marked by an ocellated black spot on the tail. Both sexes are dark mottled green in

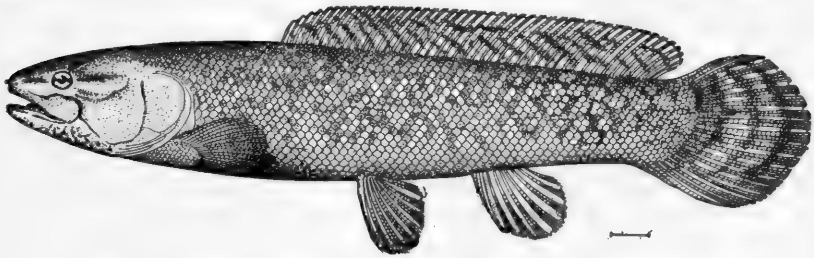


Fig. 25.—Bowfin (female), *Amia calva* Linnæus. Lake Michigan.

color. The flesh of the species is very watery, pasty, much of the substance evaporating when exposed to the air. It is ill-flavored, and is not often used as food. The species is very voracious and extremely tenacious of life. Its well-developed lung enables it to breathe even when out of the water, and it will live in the air longer than any other fish of American waters, longer even than the horned pout (*Ameiurus*) or the mud-minnow (*Umbra*). As a game fish the grindle is one of the very best, if the angler does not care for the flesh of what he catches, it being one of the hardest fighters that ever took the hook.

The *Amiidæ* retain many of the Ganoid characters, though approaching more nearly than any other of the Ganoids to the modern herring tribe. For this reason the name *Halecomorphi* (shad-formed) was given to this order by Professor Cope. The gular plate found in Amia and other Ganoids reappears in the herring-like family of *Elopidæ*, which includes the tarpon and the ten-pounder.

Woodward unites the extinct genera called *Cyclurus*, *Notæus*, *Amiopsis*, *Protamia*, *Hypamia*, and *Pappichthys* with *Amia*. *Pappichthys* (*corsoni*, etc.), from the Wyoming Eocene, is doubtless a valid genus, having but one row of teeth in each jaw, and *Amiopsis* is also recognized by Hay. Woodward refers to *Amia* the following extinct species: *Amia valenciennesi*, from the Miocene of France; *Amia macrocephala*, from the Miocene of Bohemia; and *Amia ignota*, from the Eocene of Paris. Other species of Amia are known from fragments. Several of these are from the Eocene of Wyoming and Colorado. Some of them have a much shorter dorsal fin than that of *Amia calva* and may be generically different.

The genus *Megalurus* differs from *Amia* in the still shorter dorsal fin, less than one-third the length of the back. The body is elongate and much depressed. *Megalurus lepidotus*

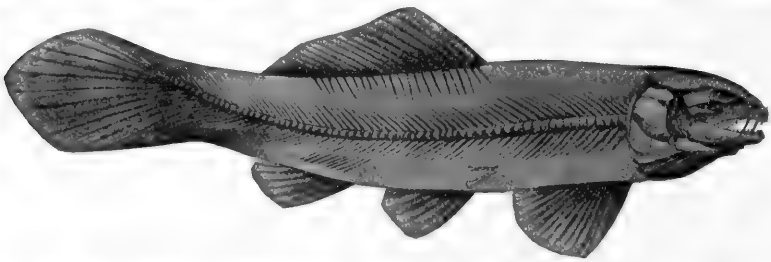


FIG. 26.—*Megalurus elegantissimus* Wagner. Family *Amiidæ*. (After Zittel.)

and several other species are found in the lithographic stones of Bavaria and elsewhere.

The Oligopleuridæ. — In the extinct family *Oligopleuridæ* the scales are cycloid, the bones of the head scarcely enameled, and the vertebræ well ossified. Fulcra are present, and the mouth is large, with small teeth. The genera are *Oligopleurus*, *Ionoscopus*, and *Spathiurus*, the species not very numerous and chiefly of the Cretaceous. *Ionoscopus cyprinoides* of the lithographic shales of Bavaria is a characteristic species.

From the three families last named, with the *Pholidophoridæ*, there is an almost perfect transition from the Ganoid fishes to teleosteans of the order of *Isospondyli*, the primitive order from which all other bony fishes are perhaps descended. The family of *Leptolepidæ*, differing from *Oligopleuridæ* in the absence of fulcra, is here placed with the *Isospondyli*, but it might about as well be regarded as Ganoid.

CHAPTER III

ISOSPONDYLI

THE **Subclass Teleostei, or Bony Fishes.**—The fishes which still remain for discussion constitute the great subclass or series of *Teleostei* (τελεός, true; οστέον, bone), or bony fishes. They lack wholly or partly the Ganoid traits, or show them only in the embryo. The tail is slightly, if at all, heterocercal; the actinosts of the pectoral fins are few and large, rarely over five in number, except among the eels; the fulcra disappear; the air-bladder is no longer cellular, except in very rare cases, nor does it assist in respiration. The optic nerves are separate, one running to each eye without crossing; the skeleton is almost entirely bony, the notochord usually disappearing entirely with age; the valves in the arterial bulb are reduced in number, and the spiral valve of the intestines disappears. Traces of each of the Ganoid traits may persist somewhere in some group, but as a whole we see a distinct specialization and a distinct movement toward the fish type, with the loss of characters distinctive of sharks, Dipnoans, and Ganoids. In a general way the skeleton of all Teleosts corresponds with that of the striped bass (see Figs 22, 23, Vol. I), and the visceral anatomy is in all cases sufficiently like that of the sunfish (Fig. 16, Vol. I).

The mesocoracoid or præcoracoid arch, found in all Ganoids, persists in the less specialized types of bony fishes, although no trace of it is found in the perch-like forms. With all this, there is developed among the bony fishes an infinite variety in details of structure. For this reason the *Teleostei* must be broken into many orders, and these orders are very different in value and in degrees of distinctness, the various groups being joined by numerous and puzzling intergradations.

Order Isospondyli.—Of the various subordinate groups of bony fishes, there can be no question as to which is most primitive in structure, or as to which stands nearest the orders of Ganoids. Earliest of the bony fishes in geological time is the order of *Isospondyli* (ἴσος, equal; σπόνδυλος, vertebra), containthe allies, recent or fossil, of the herring and the trout. This order contains those soft-rayed fishes in which the ventral fins are abdominal, a mesocoracoid or precoracoid arch is developed, and the anterior vertebræ are unmodified and essentially similar to the others. The orbitosphenoid is present in all typical forms. In certain forms of doubtful affinity (*Iniomi*) the mesocoracoid is wanting or lost in degeneration. Through the *Isospondyli* all the families of fishes yet to be considered are apparently descended, their ancestors being Ganoid fishes and, still farther back, the Crossopterygians.

Woodward gives this definition of the *Isospondyli:* "Notochord varying in persistence, the vertebral centra usually complete, but none coalesced; tail homocercal, but hæmal supports not much expanded or fused. Symplectic bone present, mandible simple, each dentary consisting only of two elements (dentary and articulo-angular), with rare rudiments of a splenoid on the inner side. Pectoral arch suspended from the cranium; precoracoid (mesocoracoid) arch present; infraclavicular plates wanting. Pelvic (ventral) fins abdominal. Scales ganoid only in the less specialized families. In the living forms air-bladder connected with the œsophagus in the adult; optic nerves decussating (without chiasma), and intestine either wanting spiral valve or with an incomplete representative of it."

The Classification of the Bony Fishes.—The classification of fishes has been greatly complicated by the variety of names applied to groups which are substantially but not quite identical one with another. The difference in these schemes of classification lies in the point of view. In all cases a single character must be brought to the front; such characters never stand quite alone, and to lay emphasis on another character is to make an alteration large or small in the name or in the boundaries of a class or order. Thus the *Ostariophysi* with the *Isospondyli*, *Haplomi*, and a few minor groups make up the great division of the *Abdominales*. These are fishes in which the

ventral fins are abdominal, that is, inserted backward, so that the pelvis is free from the clavicle, the two sets of limbs being attached to different parts of the skeleton. Most of the abdominal fishes are also soft-rayed fishes, that is, without consecutive spines in the dorsal and anal fins, and they show a number of other archaic peculiarities. The Malacopterygians (μαλακός, soft; πτερύξ, fin) of Cuvier therefore correspond very nearly to the *Abdominales*. But they are not quite the same, as the spiny-rayed barracudas and mullets have abdominal ventrals, and many unquestioned thoracic or jugular fishes, as the sea-snails and brotulids, have lost, through degeneration, all of their fin-spines.

In nearly but not quite all of the Abdominal fishes the slender tube connecting the air-bladder with the œsophagus persists through life. This character defines Müller's order of *Physostomi* (φυσός, bladder; στόμα, mouth), as opposed to his *Physoclysti* (φυσός, bladder; κλεῖστός, closed), in which this tube is present in the embryo or larva only. Thus the *Thoracices* and *Jugulares*, or fishes having the ventrals thoracic or jugular, together correspond almost exactly to the Acanthopterygians, (ακανθα, spine; πτερύξ, fin), or spiny-rayed fishes of Cuvier, or to the *Physoclysti* of Müller. The Malacopterygians, the *Abdominales*, and the *Physostomi* are in the same way practically identical groups. As the spiny-rayed fishes have mostly ctenoid scales, and the soft-rayed fishes cycloid scales, the *Physostomi* correspond roughly to Agassiz's *Cycloidei*, and the *Physoclysti* to his *Ctenoidei*.

But in none of these cases is the correspondence perfectly exact, and in any system of classification we must choose characters for primary divisions so ancient and therefore so permanent as to leave no room for exceptions. The extraordinary difficulty of doing this, with the presence of most puzzling intergradations, has led Dr. Gill to suggest that the great body of bony fishes, soft-rayed and spiny-rayed, abdominal, thoracic, and jugular alike, be placed in a single great order which he calls *Teleocephali* (τελεός, perfect; κεφαλή, head). The aberrant forms with defective skull and membrane-bones he would separate as minor offshoots from this great mass with the name of separate orders. But while the divisions of *Teleocephali*

are not strongly differentiated, their distinctive characters are real, ancient, and important, while those of the aberrant groups, called orders by Gill (as *Plectognathi*, *Pediculati*, *Hemibranchii*), are relatively modern and superficial, which is one reason why they are more easily defined. There seems to us no special advantage in the retention of a central order *Teleocephali*, from which the divergent branches are separated as distinct orders.

While our knowledge of the osteology and embryology of most of the families of fishes is very incomplete, it is evident that the relationships of the groups cannot be shown in any linear series or by any conceivable arrangement of orders and suborders. The living teleost fishes have sprung from many lines of descent, their relationships are extremely diverse, and their differences are of every possible degree of value. The ordinary schemes have magnified the value of a few common characters, at the same time neglecting other differences of equal value. No system of arrangement which throws these fishes into large groups can ever be definite or permanent.

Relationships of Isospondyli.—For our purposes we may divide the physostomous fishes as understood by Müller into several orders, the most primitive, the most generalized, and economically the most important being the order of *Isospondyli*. This order contains those bony fishes which have the anterior vertebræ unaltered (as distinguished from the *Ostariophysi*), the skull relatively complete, or at least not eel-like, the mesocoracoid typically developed, but atrophied in deep-sea forms and finally lost, the orbitosphenoid present. In all the species the ventral fins are abdominal and normally composed of more than six rays; the air-duct is developed. The scales are chiefly cycloid and the fins are without true spines. In many ways the order is more primitive than *Nematognathi*, *Plectospondyli*, or *Apodes*. It is certain that it began earlier in geological time than any of these. On the other hand, the *Isospondyli* are closely connected through the *Berycoidei* with the highly specialized fishes. The continuity of the natural series is therefore interrupted by the interposition of the side branches of Ostariophysans and eels before considering the *Haplomi* and the other transitional forms. The forms called *Iniomi*, which lack the mesocoracoid and the

orbitosphenoid, have been lately transferred to the *Haplomi* by Boulenger. This arrangement is probably a step in advance.

Ganoid traits are present in certain families of *Isospondyli*. Among these are the gular plate (found in *Amia* and the *Elopidæ*), doubtless derived from the similar structure in earlier Ganoids; additional valves in the arterial bulb in the cellular air-bladder of *Notopterus* and *Osteoglossum*, the spiral intestinal valve in *Chirocentridæ*, and the ganoid scales of the extinct *Leptolepidæ*.

The Clupeoidea.—The *Isospondyli* are divisible into numerous families, which may be grouped roughly under three subdivisions, *Clupeoidea*, the herring-like forms; the *Salmonoidea*, the trout-like forms; and the *Iniomi*, or lantern-fishes, and their allies. The last-named group should probably be removed from the order of *Isospondyli*. In the *Clupeoidea*, the allies of the great family of the herring, the shoulder-girdle is normally developed, retaining the mesocoracoid arch on its inner edge, and through the post-temporal is articulated above with the cranium. The fishes in this group lack the adipose fin which is characteristic of most of the higher or salmon-like families.

The Leptolepidæ.—Most primitive of the *Isospondyli* is the extinct family of *Leptolepidæ*, closely allied to the Ganoid families of *Pholidophoridæ* and *Oligopleuridæ*. It is composed of graceful,

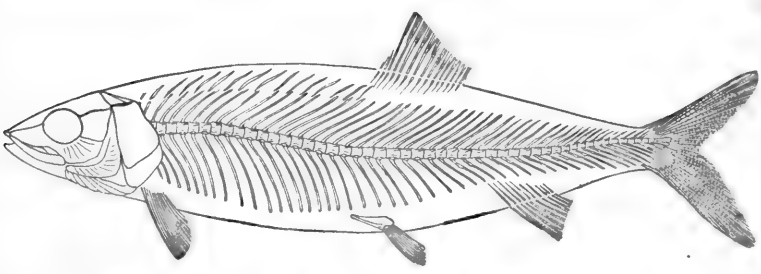


FIG. 27.—*Leptolepis dubius* Blainville, Lithographic Stone. (After Woodward.)

herring-like fishes, with the bones of the head thin but covered with enamel, and the scales thin but firm and enameled on their free portion. There are no fulcra and there is no lateral line. The vertebræ are well developed, but always pierced by the notochord. The genera are *Lycoptera*, *Leptolepis*, *Æthalion*, and *Thrissops*. In *Lycoptera* of the Jurassic of China the

vertebral centra are feebly developed, and the dorsal fin short and posterior. In *Leptolepis* the anal is short and placed behind the dorsal. There are many species, mostly from the Triassic and lithographic shales of Europe, one being found in the Cretaceous. *Leptolepis coryphænoides* and *Leptolepis dubius* are among the more common species. *Æthalion* (*knorri*) differs in the form of the jaws. In *Thrissops* the anal fin is long and opposite the dorsal. *Thrissops salmonea* is found in the lithographic stone; *Thrissops exigua* in the Cretaceous. In all these early forms there is a hard casque over the brain-cavity, as in the living types, *Amia* and *Osteoglossum*.

The Elopidæ.—The family of *Elopidæ* contains large fishes herring-like in form and structure, but having a flat membrane-

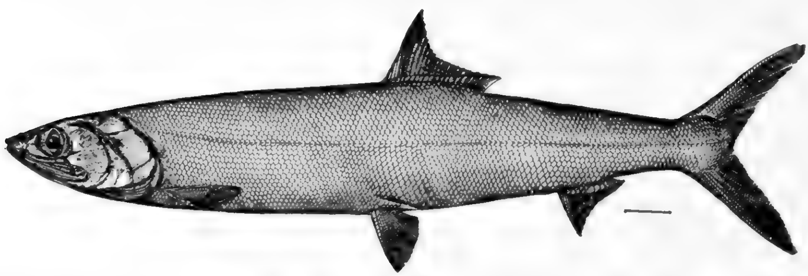


Fig. 28.—Ten-pounder, *Elops saurus* L. An ally of the earliest bony fishes. Virginia.

bone or gular plate between the branches of the lower jaw, as in the Ganoid genus *Amia*. The living species are few, abounding in the tropical seas, important for their size and numbers,

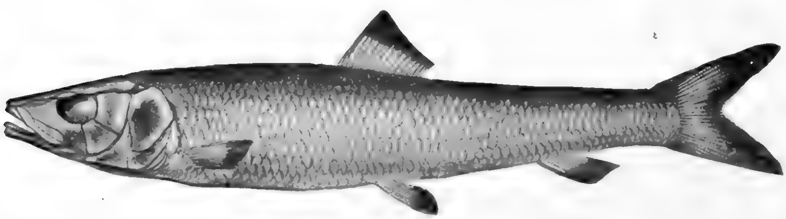


Fig. 29.—A primitive Herring-like fish, *Holcolepis lewesiensis*, Mantell, restored. Family *Elopidæ*. English Chalk. (After Woodward.)

though not valued as food-fishes save to those who, like the Hawaiians and Japanese, eat fishes raw. These people prefer

for that purpose the white-meated or soft-fleshed forms like *Elops* or *Scarus* to those which yield a better flavor when cooked.

The ten-pounder (*Elops saurus*), pike-like in form but with very weak teeth, is found in tropical America. *Elops machnata*, the jackmariddle, the awaawa of the Hawaiians, abounding in the Pacific, is scarcely if at all different.

The tarpon, called also grande écaille, silver-king, and sabalo (*Tarpon atlanticus*), is a favorite game-fish along the coasts of Florida and Carolina. It takes the hook with great spirit, and

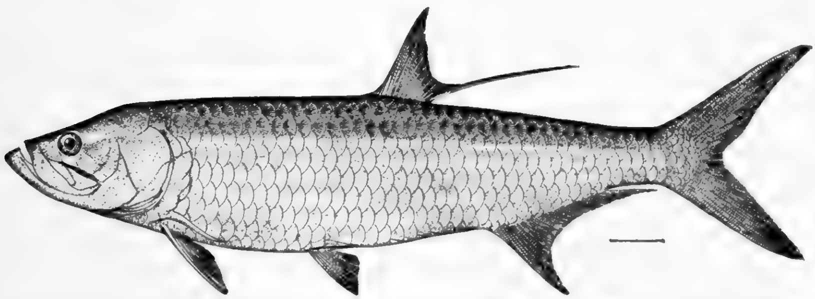


Fig. 30.—Tarpon or Grande Écaille, *Tarpon atlanticus* Cuv. & Val. Florida.

as it reaches a length of six feet or more it affords much excitement to the successful angler. The very large scales are much used in ornamental work.

A similar species of smaller size, also with the last ray of the dorsal very much produced, is *Megalops cyprinoides* of the East Indies. Other species occur in the South Seas.

Numerous fossil genera related to *Elops* are found in the Cretaceous and Tertiary rocks. *Holcolepis lewesiensis* (wrongly called *Osmeroides*) is the best-known European species. Numerous species are referred to *Elopopsis*. *Megalops prisca* and species of *Elops* also occur in the London Eocene.

In all these the large parietals meet along the median line of the skull. In the closely related family of *Spaniodontidæ* the parietals are small and do not meet. All the species of this group, united by Woodward with the *Elopidæ*, are extinct. These fishes preceded the *Elopidæ* in the Cretaceous period. Leading genera are *Thrissopater* and *Spaniodon*, the latter armed with large teeth. *Spaniodon blondeli* is from the Creta-

ceous of Mount Lebanon. Many other species are found in the European and American Cretaceous rocks, but are known from imperfect specimens only.

Sardinius, an American Cretaceous fossil herring, may stand near *Spaniodon*. *Rhacolepis buccalis* and *Notelops brama* are found in Brazil, beautifully preserved in concretions of calcareous mud supposed to be of Cretaceous age.

The extinct family of *Pachyrhizodontidæ* is perhaps allied to the *Elopidæ*. Numerous species of *Pachyrhizodus* are found in the Cretaceous of southern England and of Kansas.

The Albulidæ.—The *Albulidæ*, or lady-fishes, characterized by the blunt and rounded teeth, are found in most warm seas.

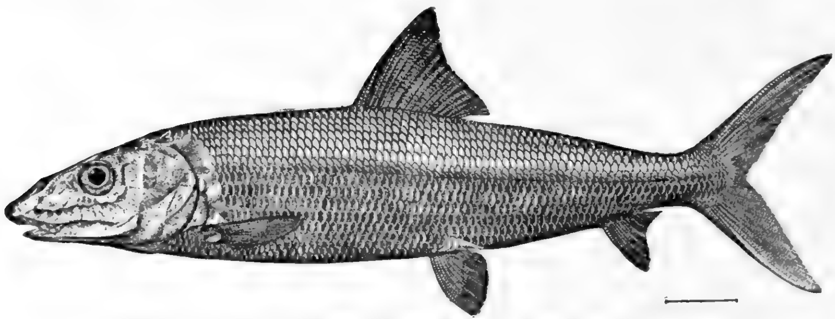


FIG. 31.—The Lady-fish, *Albula vulpes* (Linnæus). Florida.

Albula vulpes is a brilliantly silvery fish, little valued as food. The metamorphosis (see Fig. 112, Vol. I) which the larva undergoes is very remarkable. It is probably, however, more or less typical of the changes which take place with soft-rayed fishes generally, though more strongly marked in *Albula* and in certain eels than in most related forms. Fossils allied to *Albula*, *Albula oweni*, *Chanoides macropomus*, are found in the Eocene of Europe; *Syntegmodus altus* in the Cretaceous of Kansas. In *Chanoides*, the most primitive genus, the teeth are much fewer than in *Albula*. *Plethodus* and *Thryptodus*, with peculiar dental plates on the roof and floor of the mouth, probably constitute a distinct family, *Thryptodontidæ*. The species are found in European and American rocks, but are known from imperfect specimens only.

The Chanidæ.—The *Chanidæ*, or milkfishes, constitute another small archaic type, found in the tropical Pacific. They are

large, brilliantly silvery, toothless fishes, looking like enormous dace, swift in the water, and very abundant in the Gulf of

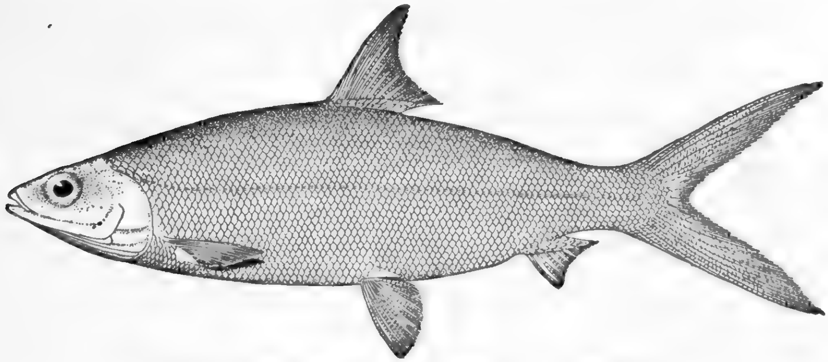


FIG. 32.—Milkfish, *Chanos chanos* (L.). Mazatlan.

California, Polynesia, and India. The single living species is the *Awa*, or milkfish, *Chanos chanos*, largely used as food in Hawaii. Species of *Prochanos* and *Chanos* occur in the Cretaceous, Eocene, and Miocene. Allied to *Chanos* is the Cretaceous genus *Ancylostylos* (*gibbus*), probably the type of a distinct family, toothless and with many-rayed dorsal.

The Hiodontidæ.—The *Hiodontidæ*, or mooneyes, inhabit the rivers of the central portion of the United States and Canada.

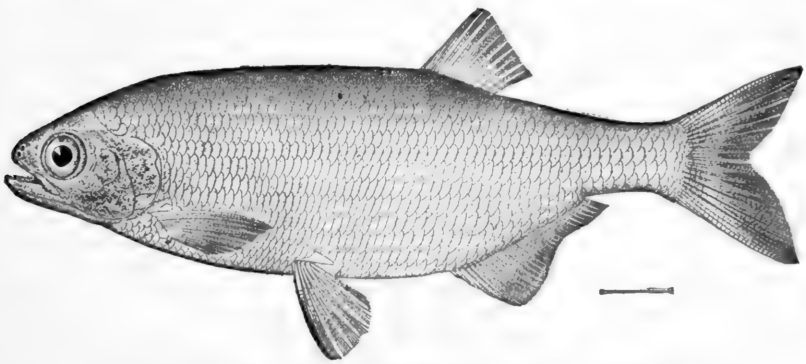


FIG. 33.—Mooneye, *Hiodon tergisus* Le Sueur. Ecorse, Mich.

They are shad-like fishes with brilliantly silvery scales and very strong sharp teeth, those on the tongue especially long. They are very handsome fishes and take the hook with spirit, but the flesh is rather tasteless and full of small bones, much like that

of the milkfish. The commonest species is *Hiodon tergisus*. No fossil *Hiodontidæ* are known.

The Pterothrissidæ.—The *Pterothrissidæ* are sea-fishes like *Albula*, but more slender and with a long dorsal fin. They live

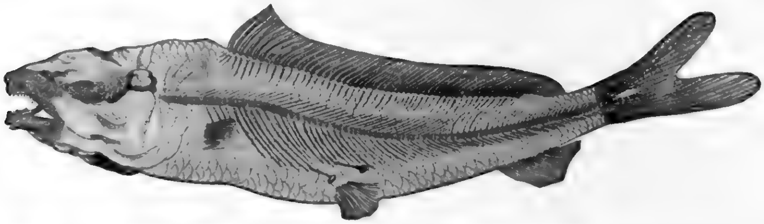


FIG. 34.—*Istieus grandis* Agassiz. Family *Pterothrissidæ*. (After Zittel.)

in deep or cold waters along the coasts of Japan, where they are known as gisu. The single species is *Pterothrissus gissu*. The fossil genus *Istieus*, from the Upper Cretaceous, probably belongs near the *Pterothrissidæ*. *Istieus grandis* is the best-known

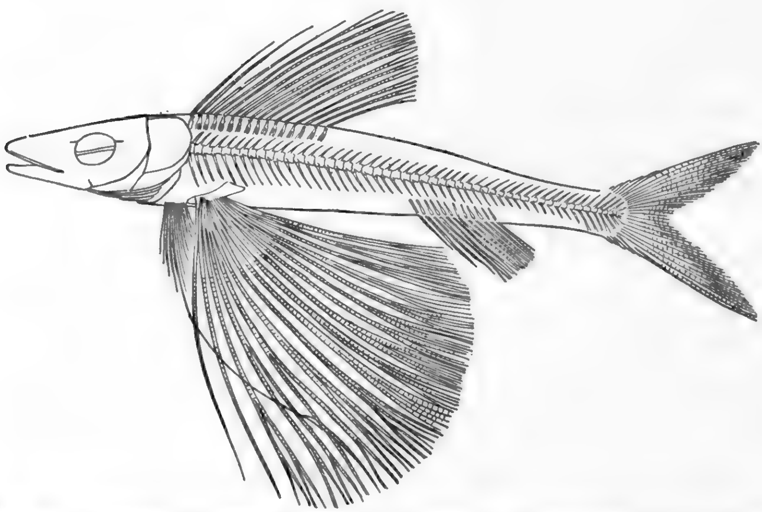


FIG. 35.—*Chirothrix libanicus* Pictet & Humbert. Cretaceous of Mt. Lebanon. (After Woodward.)

species. Another ancient family, now represented by a single species, is that of the *Chirocentridæ*, of which the living type is *Chirocentrus dorab*, a long, slender, much compressed herring-like fish, with a saw-edge on the belly, found in the East Indies,

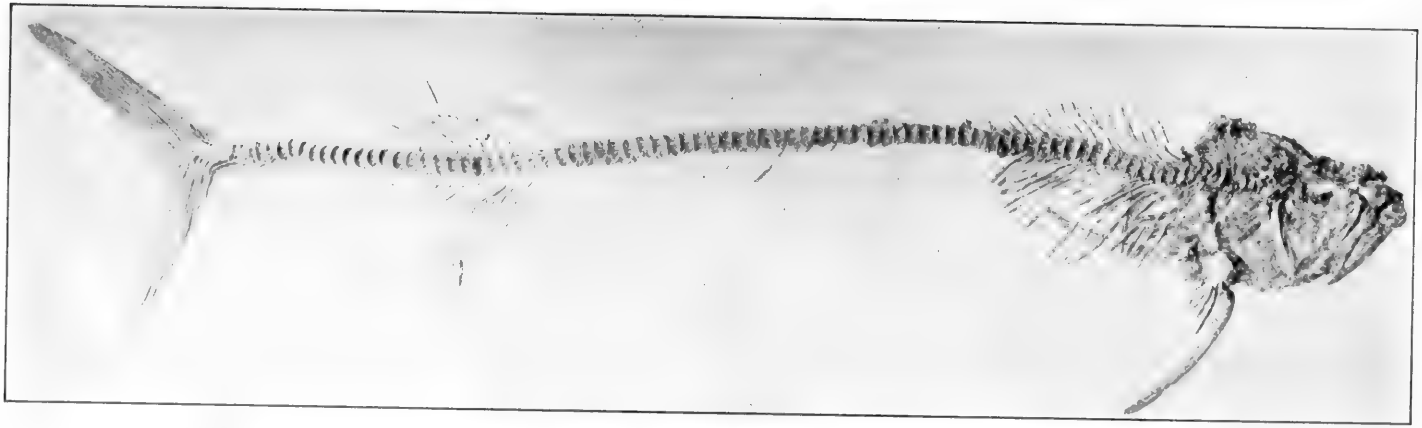


Fig. 36.—Gigantic skeleton of *Portheus molossus* Cope. (Photograph by Charles H. Sternberg.)

in which region *Chirocentrus polyodon* occurs as a fossil. Numerous fossil genera related to *Chirocentrus* are enumerated by Woodward, most of them to be referred to the related family of *Ichthyodectidæ* (*Saurodontidæ*). Of these, *Portheus*, *Ichthyodectes*, *Saurocephalus* (*Saurodon*), and *Gillicus* are represented by numerous species, some of them fishes of immense size and great voracity. *Portheus molossus*, found in the Cretaceous of Nebraska, is remarkable for its very strong teeth. Species of other genera are represented by numerous species in the Cretaceous of both the Rocky Mountain region and of Europe.

The Ctenothrissidæ.—A related family, *Ctenothrissidæ*, is represented solely by extinct Cretaceous species. In this group

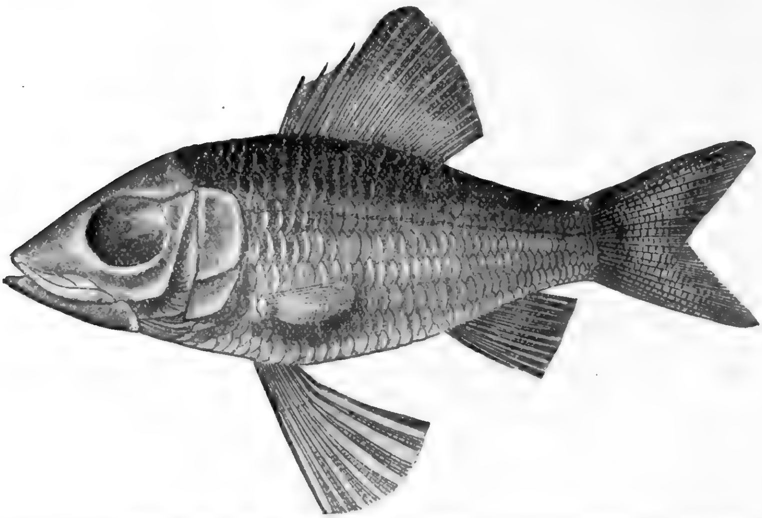


FIG. 37.—*Ctenothrissa vexillifera* Pictet, restored. Mt. Lebanon Cretaceous. (After Woodward.)

the body is robust with large scales, ctenoid in *Ctenothrissa*, cycloid in *Aulolepis*. The fins are large, the belly not serrated, and the teeth feeble. *Ctenothrissa vexillifera* is from Mount Lebanon. Other species occur in the European chalk. In the small family of *Phractolæmidæ* the interopercle, according to Boulenger, is enormously developed.

The Notopteridæ.—The *Notopteridæ* is another small family in the rivers of Africa and the East Indies. The body ends in a long and tapering fin, and, as usual in fishes which swim by

body undulations, the ventral fins are lost. The belly is doubly serrate. The air-bladder is highly complex in structure, being divided into several compartments and terminating in two horns anteriorly and posteriorly, the anterior horns being in direct communication with the auditory organ. A fossil *Notopterus, N. primævus*, is found in the same region.

The Clupeidæ.—The great herring family, or *Clupeidæ*, comprises fishes with oblong or herring-shaped body, cycloid scales, and feeble dentition. From related families it is separated by the absence of lateral line and the division of the maxillary into three pieces. In most of the genera the belly ends in a serrated edge, though in the true herring this is not very evident,

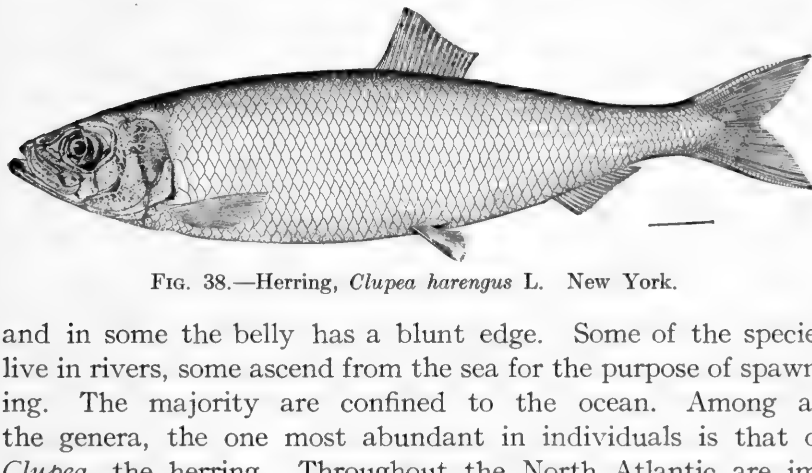


FIG. 38.—Herring, *Clupea harengus* L. New York.

and in some the belly has a blunt edge. Some of the species live in rivers, some ascend from the sea for the purpose of spawning. The majority are confined to the ocean. Among all the genera, the one most abundant in individuals is that of *Clupea*, the herring. Throughout the North Atlantic are immense schools of *Clupea harengus*. In the North Pacific on both shores another herring, *Clupea pallasi*, is equally abundant, and with the same market it would be equally valuable. As salted, dried, or smoked fish the herring is found throughout the civilized world, and its spawning and feeding-grounds have determined the location of cities.

The genus *Clupea*, of northern distribution, has the vertebræ in increased number (56), and there are weak teeth on the vomer. Several other genera are very closely related, but ranging farther south they have, with other characters, fewer (46 to 50) vertebræ. The alewife, or branch-herring (*Pomolobus pseudoharengus*), ascends the rivers to spawn and has become land-locked in

the lakes of New York. The skipjack of the Gulf of Mexico, *Pomolobus chrysochloris*, becomes very fat in the sea. The species becomes land-locked in the Ohio River, where it thrives as to numbers, but remains lean and almost useless as food. The glut-herring, *Pomolobus æstivalis*, and the sprat, *Pomolobus sprattus*, of Europe are related forms.

Very near also to the herring is the shad (*Alosa sapidissima*) of the eastern coasts of America, and its inferior relatives, the

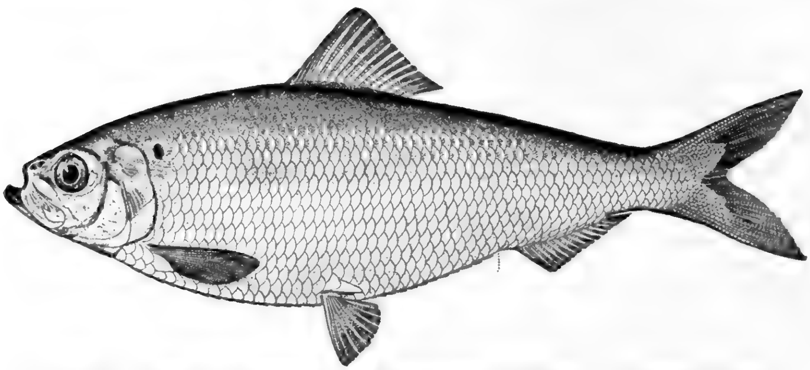


FIG. 39.—Alewife, *Pomolobus pseudoharengus* (Wilson). Potomac River.

shad of the Gulf of Mexico (*Alosa alabamæ*), the Ohio River shad (*Alosa ohiensis*), very lately discovered, the Allice shad (*Alosa alosa*) of Europe, and the Thwaite shad (*Alosa finta*). In the genus *Alosa* the cheek region is very deep, giving the head a form different from that seen in the herring.

The American shad is the best food-fish in the family, peculiarly delicate in flavor when broiled, but, to a greater degree than occurs in any other good food-fish, its flesh is crowded with small bones. The shad has been successfully introduced into the waters of California, where it abounds from Puget Sound to Point Concepcion, ascending the rivers to spawn in May as in its native region, the Atlantic coast.

The genus *Sardinella* includes species of rich flesh and feeble skeleton, excellent when broiled, when they may be eaten bones and all. This condition favors their preservation in oil as "sardines." All the species are alike excellent for this purpose. The sardine of Europe is the *Sardinella pilchardus*, known in England as the pilchard. The "Sardina de España" of

Cuba is *Sardinella pseudohispanica*, the sardine of California, *Sardinella cærulea*. *Sardinella sagax* abounds in Chile, and *Sardinella melanosticta* is the valued sardine of Japan.

In the tropical Pacific occur other valued species, largely belonging to the genus *Kowala*. The genus *Harengula* contains small species with very large, firm scales which do not fall when touched, as is generally the case with the sardines. Most common of these is *Harengula sardina* of the West Indies. Similar species occur in southern Europe and in Japan.

In *Opisthonema*, the thread-herring, the last dorsal ray is much produced, as in the gizzard-shad and the tarpon. The two species known are abundant, but of little commercial importance. Of greater value are the menhaden, or the mossbunker, *Brevoortia tyrannus*, inhabiting the sandy coasts from New England southward. It is a coarse and bony fish, rarely

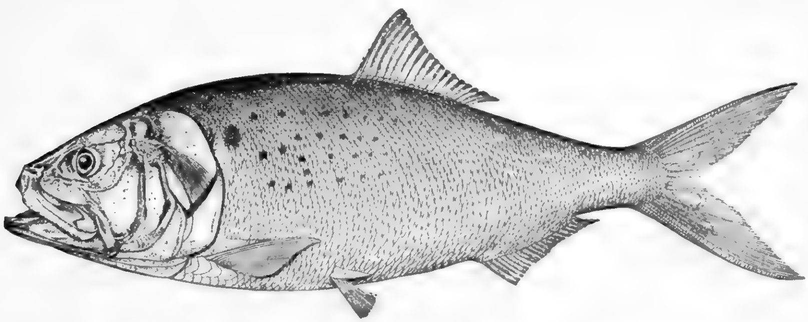


Fig. 40.—**Menhaden, *Brevoortia tyrannus* (Latrobe). Wood's Hole, Mass.**

eaten when adult, although the young in oil makes acceptable sardines. It is used chiefly for oil, the annual yield exceeding in value that of whale-oil. The refuse is used as manure, a purpose for which the fishes are often taken without preparation, being carried directly to the cornfields. From its abundance this species of inferior flesh exceeds in commercial value almost all other American fishes excepting the cod, the herring, and the quinnat salmon.

One of the most complete of fish biographies is that of Dr. G. Brown Goode on the "Natural and Economic History of Menhaden."

Numerous other herring-like forms, usually with compressed bodies, dry and bony flesh, and serrated bellies, abound in the

tropics and are largely salted and dried by the Chinese. Among these are *Ilisha elongata* of the Chinese coast. Related forms occur in Mexico and Brazil.

The round herrings, small herrings which have no serrations on the belly, are referred by Dr. Gill to the family of *Dussumieriidæ*. These are mostly small tropical fishes used as food or bait. One of these, the Kobini-Iwashi of Japan (*Stolephorus japonicus*), with a very bright silver band on the side, has considerable commercial importance. Very small herrings of this type in the West Indies constitute the genus *Jenkinsia*, named for Dr. Oliver P. Jenkins, the first to study seriously the fishes of Hawaii. Other species constitute the widely distributed genera *Etrumeus* and *Dussumieria*. *Etrumeus sardina* is the round herring of the Virginia coast. *Etrumeus micropus* is the Etrumei-Iwashi of Japan and Hawaii.

Fossil herring are plentiful and exist in considerable variety, even among the *Clupeidæ* as at present restricted. *Histiothrissa*

FIG. 41.—A fossil Herring, *Diplomystus humilis* Leidy. (From a specimen obtained at Green River, Wyo.) The scutes along the back lost in the specimen. Family *Clupeidæ*.

of the Cretaceous seems to be allied to *Dussumieria* and *Stolephorus*. Another genus, from the Cretaceous of Palestine, *Pseudoberyx* (*syriacus*, etc.), having pectinated scales, should perhaps constitute a distinct subfamily, but the general structure is like that of the herring. More evidently herring-like is *Scombroclupea* (*macrophthalma*). The genus *Diplomystus*, with enlarged scales along the back, is abundantly represented in the Eocene shales of Green River, Wyoming. Species of similar appearance, usually but wrongly referred to the same genus, occur on the coasts of Peru, Chile, and New South Wales. A specimen of *Diplomystus humilis* from Green River is here

figured. Numerous herring, referred to *Clupea*, but belonging rather to *Pomolobus*, or other non-Arctic genera, have been described from the Eocene and later rocks.

Several American fossil herring-like fishes, of the genus *Leptosomus*, as *Leptosomus percrassus*, are found in the Cretaceous of South Dakota

Fossil species doubtfully referred to *Dorosoma*, but perhaps allied rather to the thread-herring (*Opisthonema*), being herrings with a prolonged dorsal ray, are recorded from the early Tertiary of Europe. Among these is *Opisthonema doljeanum* from Austria.

The Dorosomatidæ.—The gizzard-shad, *Dorosomatidæ*, are closely related to the *Clupeidæ*, differing in the small contracted toothless mouth and reduced maxillary. The species are deep-bodied, shad-like fishes of the rivers and estuaries of eastern America and eastern Asia. They feed on mud, and the stomach is thickened and muscular like that of a fowl. As the stomach has the size and form of a hickory-nut, the common American

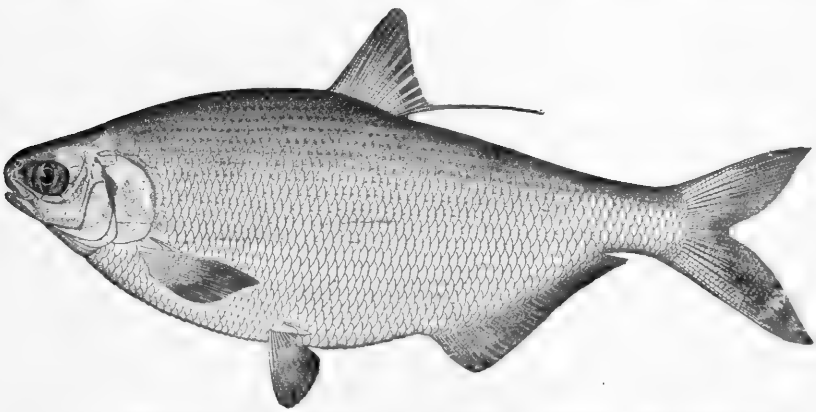


FIG. 42.—Hickory-shad, *Dorosoma cepedianum* (Le Sueur). Potomac River.

species is often called hickory-shad. The gizzard-shad are all very poor food-fish, bony and little valued, the flesh full of small bones. The belly is always serrated. In three of the four genera of *Dorosomatidæ* the last dorsal ray is much produced and whip-like. The long and slender gill-rakers serve as strainers for the mud in which these fishes find their vegetable and animal food. *Dorosoma cepedianum*, the common hickory-shad or

gizzard-shad, is found in brackish river-mouths and ponds from Long Island to Texas, and throughout the Mississippi Valley in all the large rivers. Through the canals it has entered Lake Michigan. The Konoshiro, *Clupanodon thrissa*, is equally common in China and Japan.

The Engraulididæ.—The anchovies (*Engraulididæ*) are dwarf herrings with the snout projecting beyond the very wide mouth. They are small in size and weak in muscle, found in all warm seas, and making a large part of the food of the larger fish. The genus *Engraulis* includes the anchovy of Europe, *Engraulis encrasicholus*, with similar species in California, Chile, Japan, and Australia. In this genus the vertebræ are numerous, the bones feeble, and the flesh tender and oily. The species of *Engraulis* are preserved in oil, often with spices, or are made into fish-paste, which is valued as a relish. The genus *Anchovia* replaces *Engraulis* in the tropics. The vertebræ are fewer, the

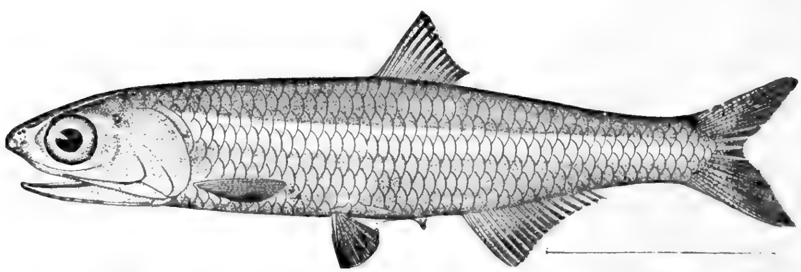


Fig. 43.—A Silver Anchovy, *Anchovia perthecata* (Goode & Bean). Tampa.

bones firm and stiff, and the flesh generally dry. Except as food for larger fish, these have little value, although existing in immense schools. Most of the species have a bright silvery band along the side. The most familiar of the very numerous species is the silver anchovy, *Anchovia browni*, which abounds in sandy bays from Cape Cod to Brazil. Several other genera occur farther southward, as well as in Asia, but *Engraulis* only is found in Europe. Fossil anchovies called *Engraulis* are recorded from the Tertiary of Europe.

Gonorhynchidæ.—To the *Isospondyli* belongs the small primitive family of *Gonorhynchidæ*, elongate fishes with small mouth, feeble teeth, no air-bladder, small scales of peculiar structure covering the head, weak dentition, the dorsal fin small, and

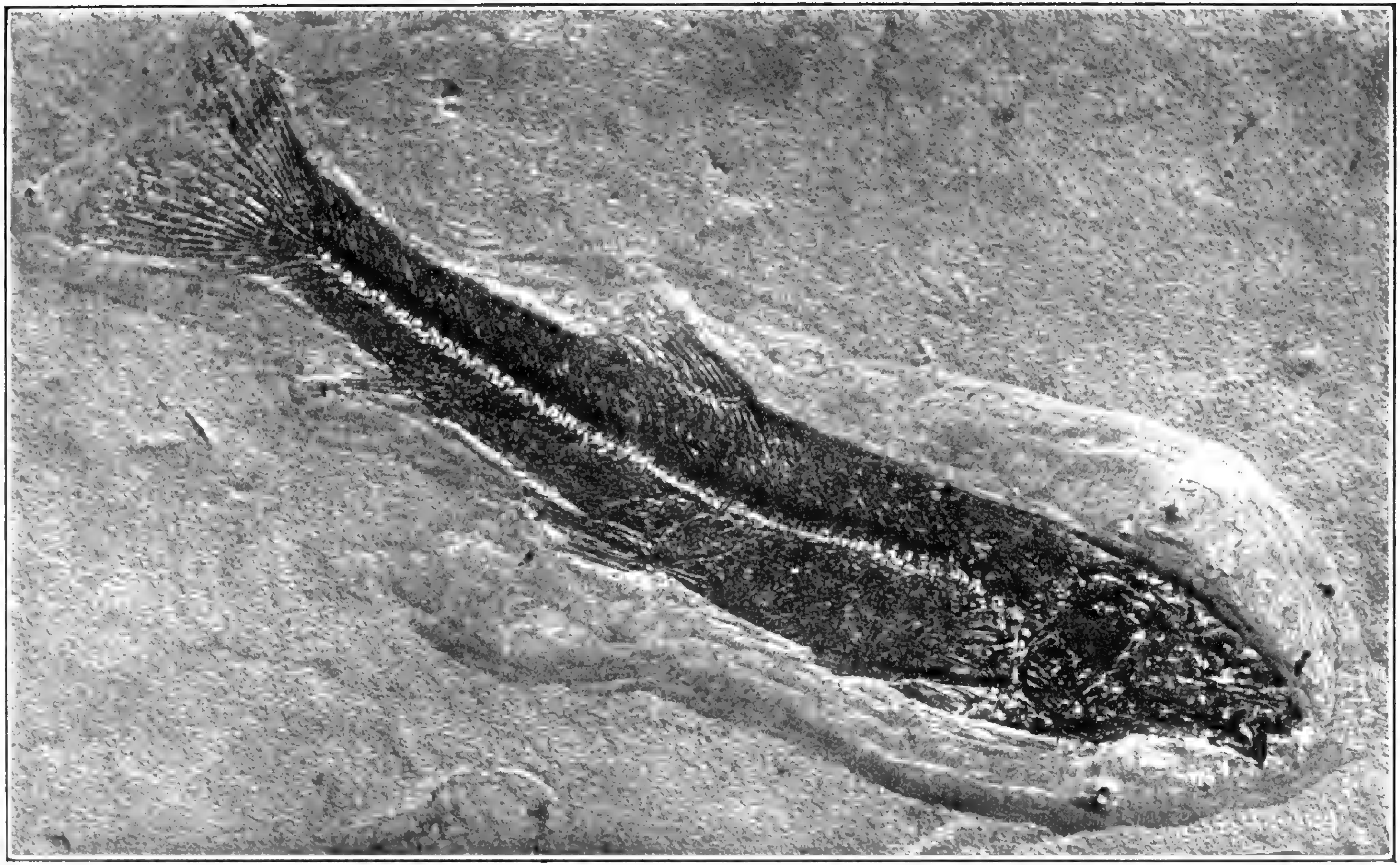


Fig. 14. *Notogoneus osculus* Cope. Green River Eocene. Family *Gonorhynchidæ*.

posterior without spines. The mesocoracoid is present as in ordinary *Isospondyli*. *Gonorhynchus abbreviatus* occurs in Japan, and *Gonorhynchus gonorhynchus* is found in Australia and about the Cape of Good Hope. Numerous fossil species occur. *Charitosomus lineolatus* and other species are found in the Cretaceous of Mount Lebanon and elsewhere. Species without teeth from the Oligocene of Europe and America are referred to the genus *Notogoneus*. *Notogoneus osculus* occurs in the Eocene fresh-water deposits at Green River, Wyoming. It bears a very strong resemblance in form to an ordinary sucker (*Catostomus*), for which reason it was once described by the name of *Protocatostomus*. The living *Gonorhynchidæ* are all strictly marine.

In the small family of *Cromeriidæ* the head and body are naked.

The Osteoglossidæ.—Still less closely related to the herring is the family of *Osteoglossidæ*, huge pike-like fishes of the tropical rivers, armed with hard bony scales formed of pieces like mosaic. The largest of all fresh-water fishes is *Arapaima gigas* of the Amazon region, which reaches a length of fifteen feet and a weight of 400 pounds. It has naturally considerable commercial importance, as have species of *Osteoglossum*, coarse river-fishes which occur in Brazil, Egypt, and the East Indies. *Heterotis nilotica* is a large fish of the Nile. In some or all of these the air-bladder is cellular or lung-like, like that of a Ganoid.

Allied to the *Osteoglossidæ* is *Phareodus* (*Dapedoglossus*), a group of large shad-like fossil fishes, with large scales of peculiar mosaic texture and with a bony casque on the head, found in fresh-water deposits of the Green River Eocene. In the perfect specimens of *Phareodus* (or *Dapedoglossus*) *testis* the first ray of the pectoral is much enlarged and serrated on its inner edge, a character which may separate these fishes as a family from the true *Osteoglossidæ*. It does not, however, appear in Cope's figures, none of his specimens having the pectorals perfect. In these fishes the teeth are very strong and sharp, the scales are very large and thin, looking like the scales of a parrot-fish, the long dorsal is opposite to the anal and similar to it, and the caudal is truncate. The end of the vertebral column is turned upward.

Other species are *Phareodus acutus*, known from the jaws; *P. encaustus* is known from a mass of thick scales with reticulate or mosaic-like surface, much as in *Osteoglossum*, and *P. æquipennis* from a small example, perhaps immature.

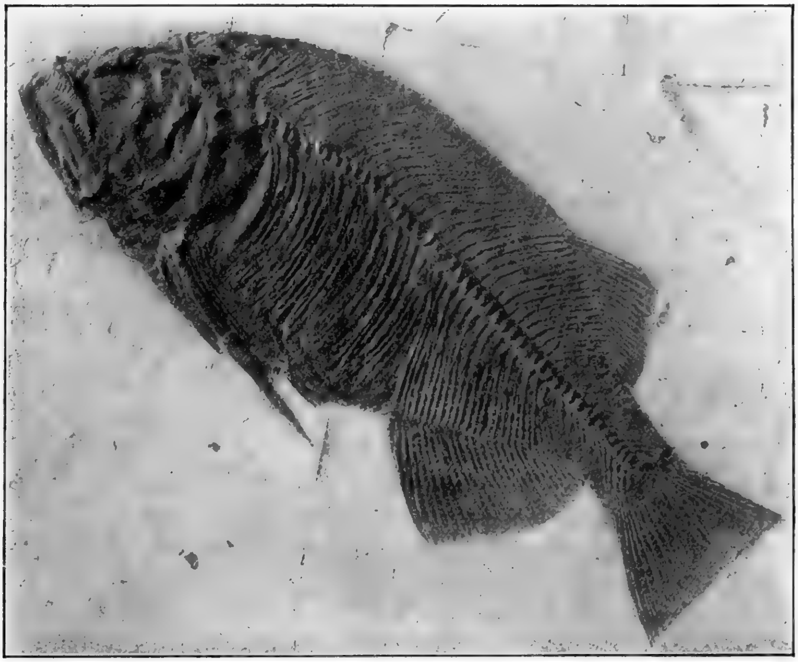


FIG. 45.—*Phareodus testis* (Cope). From a specimen 20 inches long collected at Fossil, Wyo., in the Museum of the Univ. of Wyoming. (Photograph by Prof. Wilbur C Knight.)

Phareodus testis is frequently found well preserved in the shales at Fossil Station, to the northwestward of Green River. Whether all these species possess the peculiar structure of the scales, and whether all belong to one genus, is uncertain.

In Eocene shales of England occurs *Brychætus muelleri*, a species closely related to *Phareodus*, but the scales smaller and without the characteristic reticulate or mosaic structure seen in *Phareodus encaustus*.

The Pantodontidæ.—The bony casque of *Osteoglossum* is found again in the *Pantodontidæ*, consisting of one species, *Pantodon buchholzi*, a small fish of the brooks of West Africa.

FIG. 46.—Deposits of Green River Shales, bearing *Phareodus*, at Fossil, Wyoming. (Photograph by Wilbur C. Knight.)

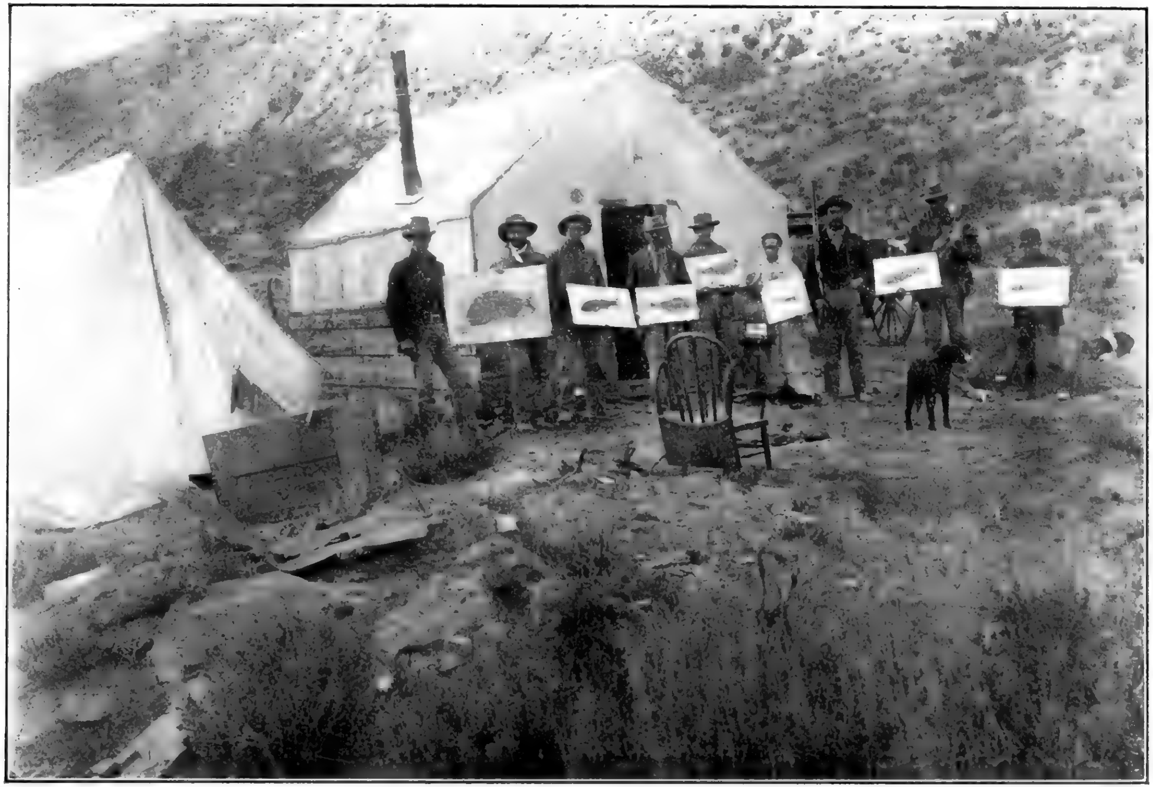


FIG. 47.—A day's catch of Fossil fishes, *Phareodus*, *Diplomystus*, etc. Green River Eocene Shales, Fossil, Wyoming. (Photograph by Prof. Wilbur C. Knight.)

As in the *Osteoglossidæ* and in the *Siluridæ*, the subopercle is wanting in *Pantodon*.

The *Alepocephalidæ* are deep-sea herring-like fishes very soft in texture and black in color, taken in the oceanic abysses. Some species may be found in almost all seas below the depth

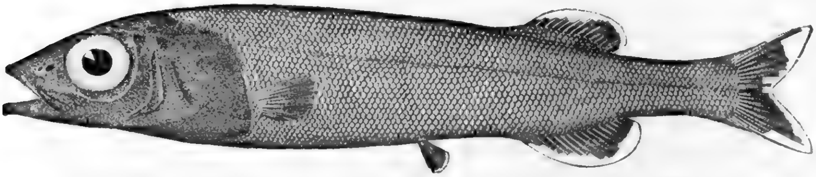


Fig. 48.—*Alepocephalus agassizii* Goode & Bean. Gulf Stream.

of half a mile. *Alepocephalus rostratus* of the Mediterranean has been long known, but most of the other genera, *Talismania*, *Mitchillina*, *Conocara*, etc., are of very recent discovery, having been brought to the surface by the deep-sea dredging of the *Challenger*, the *Albatross*, the *Blake*, the *Travailleur*, the *Talisman*, the *Investigator*, the *Hirondelle*, and the *Violante*.

CHAPTER IV

SALMONIDÆ

THE **Salmon Family.**—The series or suborder *Salmonoidea*, or allies of the salmon and trout, are characterized as a whole by the presence of the adipose fin, a structure also retained in Characins and catfishes, which have no evident affinity with the trout, and in the lantern-fishes, lizard-fishes, and trout-perches, in which the affinity is very remote. Probably these groups all have a common descent from some primitive fish having an adipose fin, or at least a fleshy fold on the back.

Of all the families of fishes, the one most interesting from almost every point of view is that of the *Salmonidæ*, the salmon family. As now restricted, it is not one of the largest families, as it comprises less than a hundred species; but in beauty, activity, gaminess, quality as food, and even in size of individuals, different members of the group stand easily with the first among fishes. The following are the chief external characteristics which are common to the members of the family:

Body oblong or moderately elongate, covered with cycloid, in scales of varying size. Head naked. Mouth terminal or somewhat inferior, varying considerably among the different species, those having the mouth largest usually having also the strongest teeth. Maxillary provided with a supplemental bone, and forming the lateral margin of the upper jaw. Pseudobranchiæ present. Gill-rakers varying with the species. Opercula complete. No barbels. Dorsal fin of moderate length, placed near the middle of the length of the body. Adipose fin well developed. Caudal fin forked. Anal fin moderate or rather long. Ventral fins nearly median in position. Pectoral fins inserted low. Lateral line present. Outline of belly rounded. Vertebræ in large number, usually about sixty.

The stomach in all the *Salmonidæ* is siphonal, and at the pylorus are many (15 to 200) comparatively large pyloric cœca. The air-bladder is large. The eggs are usually much larger than in fishes generally, and the ovaries are without special duct, the ova falling into the cavity of the abdomen before exclusion. The large size of the eggs, their lack of adhesiveness, and the readiness with which they may be impregnated, render the *Salmonidæ* peculiarly adapted for artificial culture.

The *Salmonidæ* are peculiar to the north temperate and Arctic regions, and within this range they are almost equally abundant wherever suitable waters occur. Some of the species, especially the larger ones, are marine and anadromous, living and growing in the sea, and ascending fresh waters to spawn. Still others live in running brooks, entering lakes or the sea when occasion serves, but not habitually doing so. Still others are lake fishes, approaching the shore or entering brooks in the spawning season, at other times retiring to waters of considerable depth. Some of them are active, voracious, and gamy, while others are comparatively defenseless and will not take the hook. They are divisible into ten easily recognized genera: *Coregonus*, *Argyrosomus*, *Brachymystax*, *Stenodus*, *Oncorhynchus*, *Salmo*, *Hucho*, *Cristivomer*, *Salvelinus*, and *Plecoglossus*.

Fragments of fossil trout, very imperfectly known, are recorded chiefly from Pleistocene deposits of Idaho, under the name of *Rhabdofario lacustris*. We have also received from Dr. John C. Merriam, from ferruginous sands of the same region, several fragments of jaws of salmon, in the hook-nosed condition, with enlarged teeth, showing that the present salmon-runs have been in operation for many thousands of years. Most other fragments hitherto referred to *Salmonidæ* belong to some other kind of fish.

Coregonus, the Whitefish.—The genus *Coregonus*, which includes the various species known in America as lake whitefish, is distinguishable in general by the small size of its mouth, the weakness of its teeth, and the large size of its scales. The teeth, especially, are either reduced to slight asperities, or else are altogether wanting. The species reach a length of one to three feet. With scarcely an exception they inhabit clear lakes,

and rarely enter streams except to spawn. In far northern regions they often descend to the sea; but in the latitude of the United States this is never possible for them, as they are unable to endure warm or impure water. They seldom take the hook, and rarely feed on other fishes. Numerous local varieties characterize the lakes of Scandinavia, Scotland, and Arctic Asia and America. Largest and most desirable of all these as a food-fish is the common whitefish of the Great Lakes (*Coregonus clupeiformis*), with its allies or variants in the Mackenzie and Yukon.

The species of *Coregonus* differ from each other in the form and size of the mouth, in the form of the body, and in the development of the gill-rakers.

Coregonus oxyrhynchus—the *Schnäbel* of Holland, Germany, and Scandinavia—has the mouth very small, the sharp snout projecting far beyond it. No species similar to this is found in America.

The Rocky Mountain whitefish (*Coregonus williamsoni*) has also a small mouth and projecting snout, but the latter is blunter

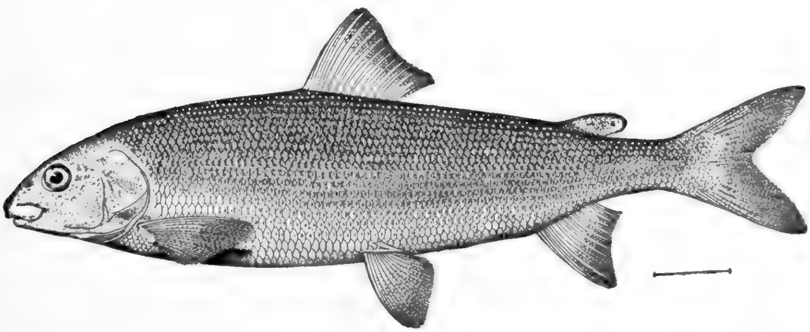


FIG. 49.—Rocky Mountain Whitefish, *Coregonus williamsoni* Girard.

and much shorter than in *C. oxyrhynchus*. This is a small species abounding everywhere in the clear lakes and streams of the Rocky Mountains and the Sierra Nevada, from Colorado to Vancouver Island. It is a handsome fish and excellent as food.

Closely allied to *Coregonus williamsoni* is the pilot-fish, shad-waiter, roundfish, or Menomonee whitefish (*Coregonus quadrilateralis*). This species is found in the Great Lakes, the Adirondack region, the lakes of New Hampshire, and thence

northwestward to the Yukon, abounding in cold deep waters, its range apparently nowhere coinciding with that of *Coregonus williamsoni*.

The common whitefish (*Coregonus clupeiformis*) is the largest in size of the species of *Coregonus*, and is unquestionably the finest as an article of food. It varies considerably in appearance with age and condition, but in general it is proportionately much deeper than any of the other small-mouthed *Coregoni*. The adult fishes develop a considerable fleshy hump at the

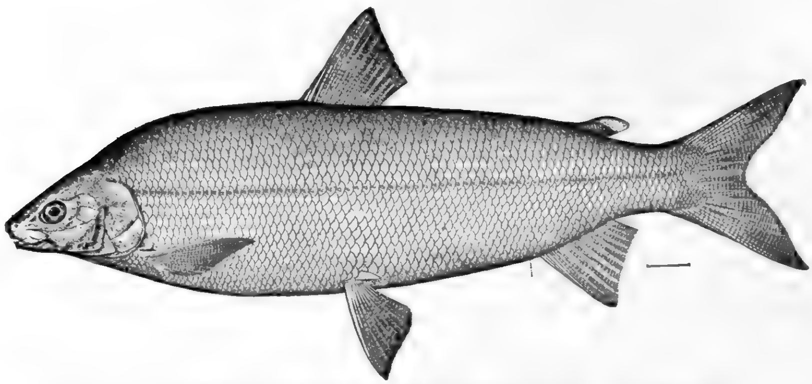


Fig. 50.—Whitefish, *Coregonus clupeiformis* Mitchill. Ecorse, Mich.

shoulders, which causes the head, which is very small, to appear disproportionately so. The whitefish spawns in November and December, on rocky shoals in the Great Lakes. Its food was ascertained by Dr. P. R. Hoy to consist chiefly of deep-water crustaceans, with a few mollusks, and larvæ of water insects. "The whitefish," writes Mr. James W. Milner, "has been known since the time of the earliest explorers as pre-eminently a fine-flavored fish. In fact there are few table-fishes its equal. To be appreciated in its fullest excellence it should be taken fresh from the lake and broiled. Father Marquette, Charlevoix, Sir John Richardson—explorers who for months at a time had to depend upon the whitefish for their staple article of food—bore testimony to the fact that they never lost their relish for it, and deemed it a special excellence that the appetite never became cloyed with it." The range of the whitefish extends from the lakes of New York and New England northward to the Arctic Circle. The "Otsego bass" of Otsego

Lake in New York, celebrated by De Witt Clinton, is a local form of the ordinary whitefish.

Allied to the American whitefish, but smaller in size, is the Lavaret, Weissfisch, Adelfisch, or Weissfelchen (*Coregonus lavaretus*), of the mountain lakes of Switzerland, Germany, and Sweden. *Coregonus kennicotti*, the muksun, and *Coregonus nelsoni*, the humpback whitefish, are found in northern Alaska and in the Yukon. Several other related species occur in northern Europe and Siberia.

Another American species is the Sault whitefish, Lake Whiting or Musquaw River whitefish (*Coregonus labradoricus*). Its teeth are stronger, especially on the tongue, than in any of our other species, and its body is slenderer than that of the whitefish. It is found in the upper Great Lakes, in the Adirondack region, in Lake Winnipeseogee, and in the lakes of Maine and New Brunswick. It is said to rise to the fly in the Canadian lakes. This species runs up the St. Mary's River, from Lake Huron to Lake Superior, in July and August. Great numbers are snared or speared by the Indians at this season at the Sault Ste. Marie.

In the breeding season the scales are sometimes thickened or covered with small warts, as in the male *Cyprinidæ*.

Argyrosomus, the Lake Herring.—In the genus *Argyrosomus* the mouth is larger, the premaxillary not set vertical, but extending forward on its lower edge, and the body is more elongate and more evenly elliptical. The species are more active and predaceous than those of *Coregonus* and are, on the whole, inferior as food.

The smallest and handsomest of the American whitefish is the cisco of Lake Michigan (*Argyrosomus hoyi*). It is a slender fish, rarely exceeding ten inches in length, and its scales have the brilliant silvery luster of the mooneye and the ladyfish.

The lake herring, or cisco (*Argyrosomus artedi*), is, next to the whitefish, the most important of the American species. It is more elongate than the others, and has a comparatively large mouth, with projecting under-jaw. It is correspondingly more voracious, and often takes the hook. During the spawning season of the whitefish the lake herring feeds on the ova of the latter, thereby doing a great amount of mischief. As food

this species is fair, but much inferior to the whitefish. Its geographical distribution is essentially the same, but to a greater degree it frequents shoal waters. In the small lakes around Lake Michigan, in Indiana and Wisconsin (Tippecanoe, Geneva, Oconomowoc, etc.), the cisco has long been established; and in these waters its habits have undergone some change, as has also its external appearance. It has been recorded as a distinct species, *Argyrosomus sisco*, and its excellence as a game-fish has been long appreciated by the angler. These lake ciscoes remain for most of the year in the depths of the lake, coming to the surface only in search of certain insects, and to shallow water only in the spawning season. This periodical disappearance of the cisco has led to much foolish discussion as to the probability of their returning by an underground passage to Lake

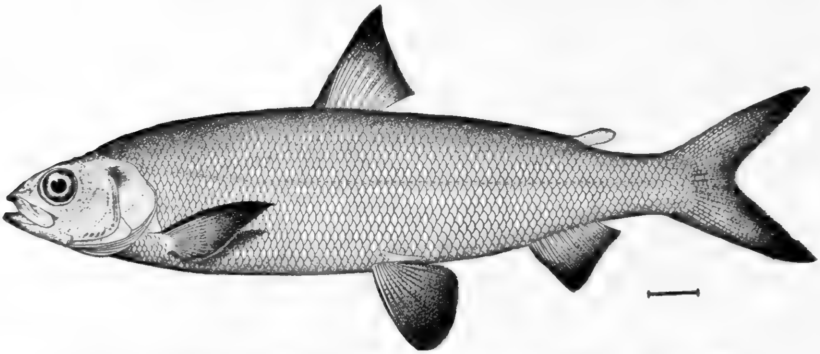


Fig. 51.—Bluefin Cisco, *Argyrosomus nigripinnis* Gill. Sheboygan.

Michigan during the periods of their absence. One author, confounding "cisco" with "siscowet," has assumed that this underground passage leads to Lake Superior, and that the cisco is identical with the fat lake trout which bears the latter name. The name "lake herring" alludes to the superficial resemblance which this species possesses to the marine herring, a fish of quite a different family.

Closely allied to the lake herring is the bluefin of Lake Michigan and of certain lakes in New York (*Argyrosomus nigripinnis*), a fine large species inhabiting deep waters, and recognizable by the blue-black color of its lower fins. In the lakes of central New York are found two other species, the so-called lake smelt (*Argyrosomus osmeriformis*) and the long-jaw (*Argyrosomus

prognathus). *Argyrosomus lucidus* is abundant in Great Bear Lake. In Alaska and Siberia are still other species of the cisco type (*Argyrosomus laurettæ, A. pusillus, A. alascanus*); and in Europe very similar species are the Scotch vendace (*Argyrosomus vandesius*) and the Scandinavian Lok-Sild (lake herring), as well as others less perfectly known.

The Tullibee, or "mongrel whitefish" (*Argyrosomus tullibee*), has a deep body, like the shad, with the large mouth of the ciscoes. It is found in the Great Lake region and northward, and very little is known of its habits. A similar species (*Argyrosomus cyprinoides*) is recorded from Siberia—a region which is peculiarly suited for the growth of the *Coregoni*, but in which the species have never received much study.

Brachymystax and Stenodus, the Inconnus.—Another little-known form, intermediate between the whitefish and the salmon,

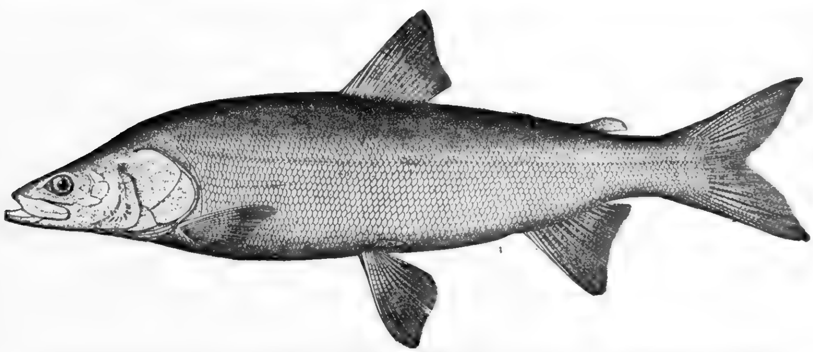


Fig. 52.—Inconnu, *Stenodus mackenziei* (Richardson). Nulato, Alaska.

is *Brachymystax lenock*, a large fish of the mountain streams of Siberia. Only the skins brought home by Pallas a century ago are yet known. According to Pallas, it sometimes reaches a weight of eighty pounds.

Still another genus, intermediate between the whitefish and the salmon, is *Stenodus*, distinguished by its elongate body, feeble teeth, and projecting lower jaw. The Inconnu, or Mackenzie River salmon, known on the Yukon as "charr" (*Stenodus mackenziei*), belongs to this genus. It reaches a weight of twenty pounds or more, and in the far north is a food-fish of good quality. It runs in the Yukon as far as White Horse Rapids. Not much is recorded of its habits, and few specimens exist in

museums. A species of *Stenodus* called *Stenodus leucichthys* inhabits the Volga, Obi, Lena, and other northern rivers; but as yet little is definitely known of the species.

Oncorhynchus, the Quinnat Salmon.—The genus *Oncorhynchus* contains the salmon of the Pacific. They are in fact, as well as in name, the king salmon. The genus is closely related to *Salmo*, with which it agrees in general as to the structure of its vomer, and from which it differs in the increased number of anal rays, branchiostegals, pyloric cœca, and gill-rakers. The character most convenient for distinguishing *Oncorhynchus*, young or old, from all the species of *Salmo*, is the number of developed rays in the anal fin. These in *Oncorhynchus* are thirteen to twenty, in *Salmo* nine to twelve.

The species of *Oncorhynchus* have long been known as anadromous salmon, confined to the North Pacific. The species were first made known nearly one hundred and fifty years ago by that most exact of early observers, Steller, who, almost simultaneously with Krascheninnikov, another early investigator, described and distinguished them with perfect accuracy under their Russian vernacular names. These Russian names were, in 1792, adopted by Walbaum as specific names in giving to these animals a scientific nomenclature. Five species of *Oncorhynchus* are well known on both shores of the North Pacific, besides one other in Japan. These have been greatly misunderstood by early observers on account of the extraordinary changes due to differences in surroundings, in sex, and in age, and in conditions connected with the process of reproduction.

There are five species of salmon (*Oncorhynchus*) in the waters of the North Pacific, all found on both sides, besides one other which is known only from the waters of Japan. These species may be called: (1) the quinnat, or king-salmon, (2) the blue-back salmon, or redfish, (3) the silver salmon, (4) the dog-salmon, (5) the humpback salmon, and (6) the masu; or (1) *Oncorhynchus tschawytscha*, (2) *Oncorhynchus nerka*, (3) *Oncorhynchus milktschitsch*, (4) *Oncorhynchus keta*, (5) *Oncorhynchus gorbuscha*, (6) *Oncorhynchus masou*. All these species save the last are now known to occur in the waters of Kamchatka, as well as in those of Alaska and Oregon. These species, in all their varied conditions, may usually be distinguished by the

characters given below. Other differences of form, color, and appearance are absolutely valueless for distinction, unless specimens of the same age, sex, and condition are compared.

The quinnat salmon (*Oncorhynchus tschawytscha*),* called quinnat, tyee, chinook, or king-salmon, has an average weight of 22 pounds, but individuals weighing 70 to 100 pounds are occasionally taken. It has about 16 anal rays, 15 to 19 branchiostegals, 23 (9 + 14) gill-rakers on the anterior gill-arch, and 140 to 185 pyloric cœca. The scales are comparatively large, there being from 130 to 155 in a longitudinal series. In the spring the body is silvery, the back, dorsal fin, and caudal fin having more or less of round black spots, and the sides of the head having a peculiar tin-colored metallic luster. In the fall

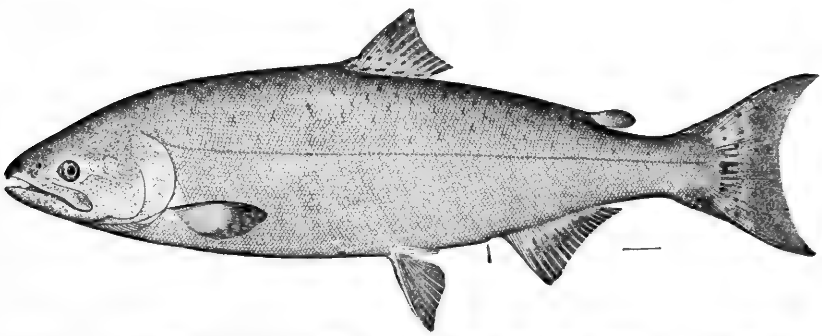


FIG. 53.—Quinnat Salmon (female), *Oncorhynchus tschawytscha* (Walbaum). Columbia River.

the color is often black or dirty red, and the species can then be distinguished from the dog-salmon by its larger size and by its technical characters. The flesh is rich and salmon-red, becoming suddenly pale as the spawning season draws near.

The blue-back salmon (*Oncorhynchus nerka*),† also called red salmon, sukkegh, or sockeye, usually weighs from 5 to 8 pounds. It has about 14 developed anal rays, 14 branchioste-

* For valuable accounts of the habits of this species the reader is referred to papers by the late Cloudsley Rutter, ichthyologist of the *Albatross*, in the publications of the United States Fish Commission, the *Popular Science Monthly*, and the *Overland Monthly*.

† For valuable records of the natural history of this species the reader is referred to various papers by Dr. Barton Warren Evermann in the Bulletins of the United States Fish Commission and elsewhere.

gals, and 75 to 95 pyloric cœca. The gill-rakers are more numerous than in any other salmon, the number being usually about

Fig. 54.—King-salmon grilse, *Oncorhynchus tschawytscha* (Walbaum). (Photograph by Cloudsley Rutter.)

39 (16+23). The scales are larger, there being 130 to 140 in the lateral line. In the spring the form is plumply rounded, and the color is a clear bright blue above, silvery below, and everywhere immaculate. Young fishes often show a few round black spots, which disappear when they enter the sea. Fall specimens in the lakes are bright crimson in color, the head clear olive-green, and they become in a high degree hook-nosed and slab-sided, and bear little resemblance to the spring run. Young spawning male grilse follow the changes which take place in the adult, although often not more than half a pound in weight.

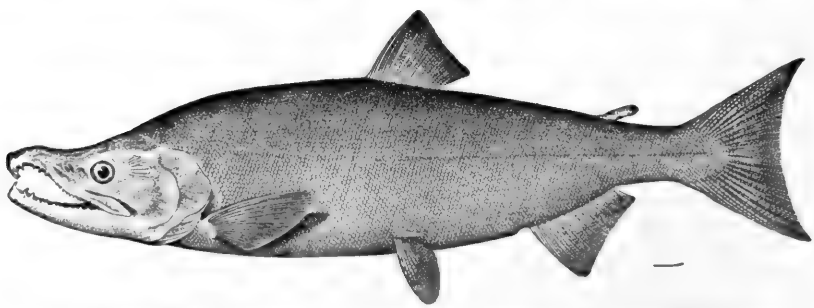


Fig. 55.—Male Red Salmon in September, *Oncorhynchus nerka* (Walbaum). Payette Lake, Idaho.

These little fishes often appear in mountain lakes, but whether they are landlocked or have come up from the sea is still un-

settled. These dwarf forms, called kokos by the Indians and benimasu in Japan, form the subspecies *Oncorhynchus nerka kennerlyi*. The flesh in this species is firmer than that of any other and very red, of good flavor, though drier and less rich than the king-salmon.

The silver salmon, or coho (*Oncorhynchus milktschitsch*, or *kisutch*), reaches a weight of 5 to 8 pounds. It has 13 developed rays in the anal, 13 branchiostegals, 23 (10 + 13) gill-rakers, and 45 to 80 pyloric cœca. There are about 127 scales in the lateral line. The scales are thin and all except those of the lateral line readily fall off. This feature distinguishes the species readily from the red salmon. In color it is silvery in spring, greenish above, and with a few faint black spots on the upper parts only. In the fall the males are mostly of a dirty red. The flesh in this species is of excellent flavor, but pale in color, and hence less valued than that of the quinnat and the red salmon.

The dog-salmon, calico salmon, or chum, called saké in Japan (*Oncorhynchus keta*), reaches an average weight of about 7 to 10 pounds. It has about 14 anal rays, 14 branchiostegals, 24 (9 + 15) gill-rakers, and 140 to 185 pyloric cœca. There are about 150 scales in the lateral line. In spring it is dirty silvery, immaculate, or sprinkled with small black specks, the fins dusky, the sides with faint traces of gridiron-like bars. In the fall the male is brick-red or blackish, and its jaws are greatly distorted. The pale flesh is well flavored when fresh, but pale and mushy in texture and muddy in taste when canned. It is said to take salt well, and great numbers of salt dog-salmon are consumed in Japan.

The humpback salmon, or pink salmon (*Oncorhynchus gorbuscha*), is the smallest of the American species, weighing from 3 to 5 pounds. It has usually 15 anal rays, 12 branchiostegals, 28 (13 + 15) gill-rakers, and about 180 pyloric cœca. Its scales are much smaller than in any other salmon, there being 180 to 240 in the lateral line. In color it is bluish above, silvery below, the posterior and upper parts with many round black spots, the caudal fin always having a few large black spots oblong in form. The males in fall are dirty red, and are more extravagantly distorted than in any other of the *Salmonidæ*.

The flesh is softer than in the other species; it is pale in color, and, while of fair flavor when fresh, is distinctly inferior when canned.

The masu, or yezomasu (*Oncorhynchus masou*), is very similar to the humpback, the scales a little larger, the caudal without

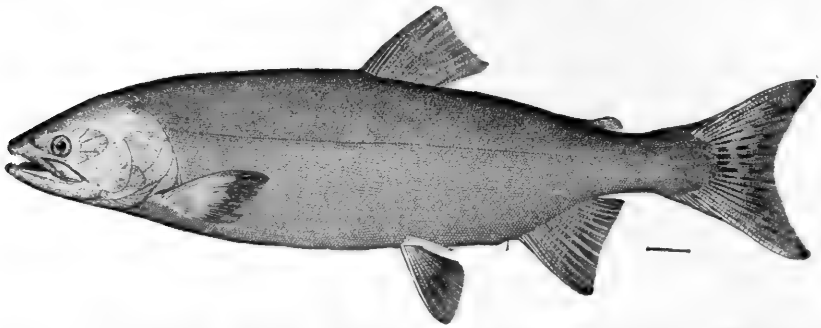


Fig. 56.—Humpback Salmon (female), *Oncorhynchus gorbuscha* (Walbaum). Cook's Inlet.

black spots, the back usually immaculate. It is one of the smaller salmon, and is fairly abundant in the streams of Hokkaido, the island formerly known as Yezo.

Of these species the blue-back or red salmon predominates in Frazer River and in most of the small rivers of Alaska, includ-

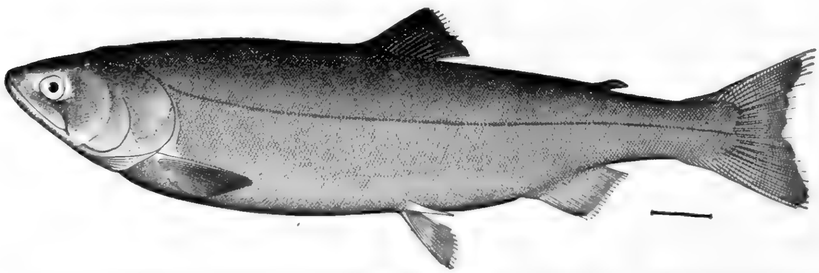


Fig. 57.—Masu (female), *Oncorhynchus masou* (Brevoort). Aomori, Japan.

ing all those which flow from lakes. The greatest salmon rivers of the world are the Nushegak and Karluk in Alaska, with the Columbia River, Frazer River, and Sacramento River farther south. The red and the silver salmon predominate in Puget Sound, the quinnat in the Columbia and the Sacramento, and the silver salmon in most of the smaller streams along the coast. All the species occur, however, from the Columbia northward;

but the blue-back is not found in the Sacramento. Only the quinnat and the dog-salmon have been noticed south of San Francisco. In Japan *keta* is by far the most abundant species of salmon. It is known as saké, and largely salted and sold in the markets. *Nerka* is known in Japan only as landlocked in Lake Akan in northern Hokkaido. *Milktschitsch* is generally common, and with *masou* is known as masu, or small salmon, as distinguished from the large salmon, or saké. *Tschawytscha* and *gorbuscha* are unknown in Japan. *Masou* has not been found elsewhere.

The quinnat and blue-back salmon, the "noble salmon," habitually "run" in the spring, the others in the fall. The usual order of running in the rivers is as follows: *tschawytscha, nerka, milktschitsch, gorbuscha, keta.* Those which run first go farthest. In the Yukon the quinnat runs as far as Caribou Crossing and Lake Bennett, 2250 miles. The red salmon runs to "Forty-Mile," which is nearly 1800 miles. Both ascend to the head of the Columbia, Fraser, Nass, Skeena, Stikeen, and Taku rivers. The quinnat runs practically only in the streams of large size, fed with melting snows; the red salmon only in streams which pass through lakes. It spawns only in small streams at the head of a lake. The other species spawn in almost any fresh water and only close to the sea.

The economic value of the spring-running salmon is far greater than that of the other species, because they can be captured in numbers when at their best, while the others are usually taken only after deterioration.

The habits of the salmon in the ocean are not easily studied. Quinnat and silver salmon of all sizes are taken with the seine at almost any season in Puget Sound and among the islands of Alaska. This would indicate that these species do not go far from the shore. The silver salmon certainly does not. The quinnat pursues the schools of herring. It takes the hook freely in Monterey Bay, both near the shore and at a distance of six to eight miles out. We have reason to believe that these two species do not necessarily seek great depths, but probably remain not very far from the mouth of the rivers in which they were spawned. The blue-back or red salmon certainly seeks deeper water, as it is seldom or never taken with the seine along shore, and it is known to enter the Strait of Fuca in

July, just before the running season, therefore coming in from the open sea. The great majority of the quinnat salmon, and probaby all the blue-back salmon, enter the rivers in the spring. The run of the quinnat begins generally at the last of March; it lasts, with various modifications and interruptions, until the actual spawning season in November, the greatest run being in early June in Alaska, in July in the Columbia, The run begins earliest in the northernmost rivers, and in the longest streams, the time of running and the proportionate amount in each of the subordinate runs varying with each different river. In general the runs are slack in the summer and increase with the first high water of autumn. By the last of August only straggling blue-backs can be found in the lower course of any stream; but both in the Columbia and in the Sacramento the quinnat runs in considerable numbers at least till October. In the Sacramento the run is greatest in the fall, and more run in the summer than in spring. In the Sacramento and the smaller rivers southward there is a winter run, beginning in December. The spring quinnat salmon ascends only those rivers which are fed by the melting snows from the mountains and which have sufficient volume to send their waters well out to sea. Those salmon which run in the spring are chiefly adults (supposed to be at least three years old). Their milt and spawn are no more developed than at the same time in others of the same species which have not yet entered the rivers. It would appear that the contact with cold fresh water, when in the ocean, in some way causes them to run towards it, and to run before there is any special influence to that end exerted by the development of the organs of generation. High water on any of these rivers in the spring is always followed by an increased run of salmon. The salmon-canners think—and this is probably true—that salmon which would not have run till later are brought up by the contact with the cold water. The cause of this effect of cold fresh water is not understood. We may call it an instinct of the salmon, which is another way of expressing our ignorance. In general it seems to be true that in those rivers and during those years when the spring run is greatest the fall run is least to be depended on.

The blue-back salmon runs chiefly in July and early August,

beginning in late June in Chilcoot River, where some were found actually spawning July 15; beginning after the middle of July in Frazer River.

As the season advances, smaller and younger salmon of these species (quinnat and blue-back) enter the rivers to spawn, and in the fall these young specimens are very numerous. We have thus far failed to notice any gradations in size or appearance of these young fish by which their ages could be ascertained. It is, however, probable that some of both sexes reproduce at the age of one year. In Frazer River, in the fall, quinnat male grilse of every size, from eight inches upwards, were running, the milt fully developed, but usually not showing the hooked jaws and dark colors of the older males. Females less than eighteen inches in length were not seen. All of either sex, large and small, then in the river had the ovaries or milt developed. Little blue-backs of every size, down to six inches, are also found in the upper Columbia in the fall, with their organs of generation fully developed. Nineteen-twentieths of these young fish are males, and some of them have the hooked jaws and red color of the old males. Apparently all these young fishes, like the old ones, die after spawning.

The average weight of the adult quinnat in the Columbia, in the spring, is twenty-two pounds; in the Sacramento, about sixteen. Individuals weighing from forty to sixty pounds are frequently found in both rivers, and some as high as eighty or even one hundred pounds are recorded, especially in Alaska, where the species tends to run larger. It is questionable whether these large fishes are those which, of the same age, have grown more rapidly; those which are older, but have for some reason failed to spawn; or those which have survived one or more spawing seasons. All these origins may be possible in individual cases. There is, however, no positive evidence that any salmon of the Pacific survives the spawning season.

Those fish which enter the rivers in the spring continue their ascent till death or the spawning season overtakes them. Doubtless not one of them ever returns to the ocean, and a large proportion fail to spawn. They are known to ascend the Sacramento to its extreme head-waters, about four hundred miles. In the Columbia they ascend as far as the Bitter Root and Saw-

tooth mountains of Idaho, and their extreme limit is not known. This is a distance of nearly a thousand miles. In the Yukon a few ascend to Caribou Crossing and Lake Bennett, 2250 miles. At these great distances, when the fish have reached the spawning grounds, besides the usual changes of the breeding season their bodies are covered with bruises, on which patches of white fungus (*Saprolegnia*) develop. The fins become mutilated, their eyes are often injured or destroyed, parasitic worms gather in their gills, they become extremely emaciated, their flesh becomes white from the loss of oil; and as soon as the spawning act is accomplished, and sometimes before, *all* of them die. The ascent of the Cascades and the Dalles of the Columbia causes the injury or death of a great many salmon.

When the salmon enter the river they refuse to take bait, and their stomachs are always found empty and contracted.

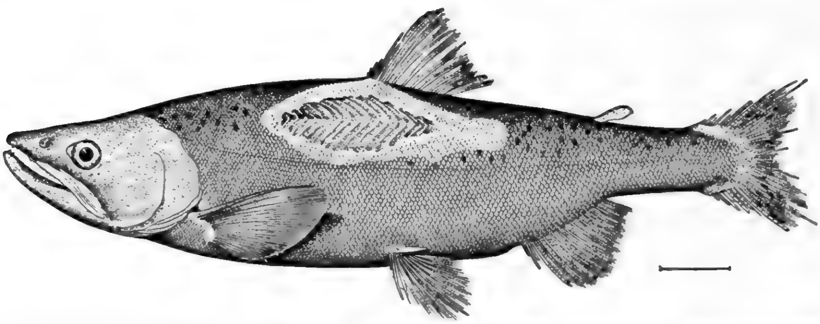


Fig. 58.—Red Salmon (mutilated dwarf male, after spawning), *Oncorhynchus nerka* (Walbaum). Alturas Lake, Idaho

In the rivers they do not feed; and when they reach the spawning grounds their stomachs, pyloric cœca and all, are said to be no larger than one's finger. They will sometimes take the fly, or a hook baited with salmon-roe, in the clear waters of the upper tributaries, but this is apparently solely out of annoyance, snapping at the meddling line. Only the quinnat and blue-back (there called redfish) have been found at any great distance from the sea, and these (as adult fishes) only in late summer and fall.

The spawning season is probably about the same for all the species. It varies for each of the different rivers, and for different parts of the same river. It doubtless extends from July to

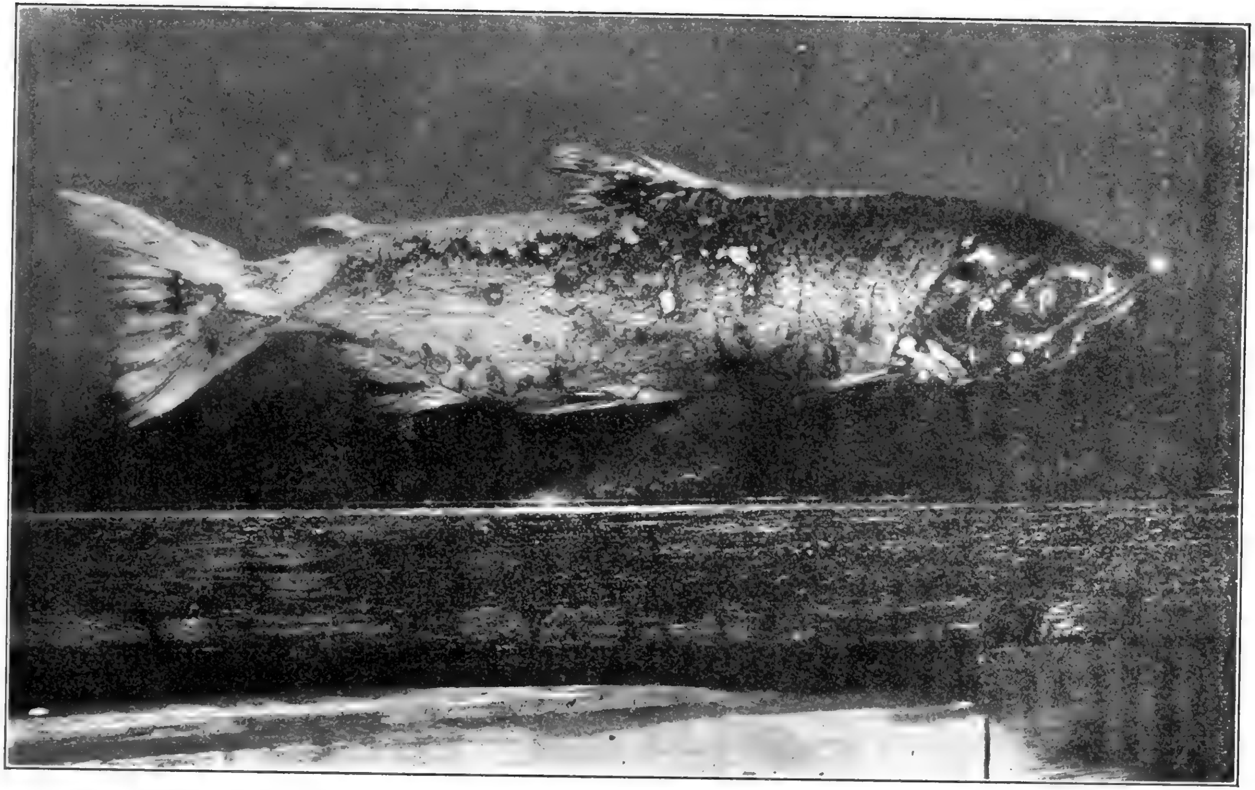


FIG. 59.—Young Male Quinnat Salmon, *Oncorhynchus tschawytscha*, dying after spawning. Sacramento River. (Photograph by Cloudsley Rutter.)

December, and takes place usually as soon as the temperature of the water falls to 54°. The manner of spawning is probably similar for all the species. In the quinnat the fishes pair off; the male, with tail and snout, excavates a broad, shallow "nest" in the gravelly bed of the stream, in rapid water, at a depth of one to four feet and the female deposits her eggs in it. They then float down the stream tail foremost, the only fashion in which salmon descend to the sea. As already stated, in the head-waters of the large streams, unquestionably, all die; it is the belief of the writer that none ever survive. The young hatch in sixty days, and most of them return to the ocean during the high water of the spring. They enter the river as adults at the age of about four years.

The salmon of all kinds in the spring are silvery, spotted or not according to the species, and with the mouth about equally symmetrical in both sexes. As the spawning season approaches the female loses her silvery color, becomes more slimy, the scales on the back partly sink into the skin, and the flesh changes from salmon-red and becomes variously paler, from the loss of oil; the degree of paleness varying much with individuals and with inhabitants of different rivers. In the Sacramento the flesh of the quinnat, in either spring or fall, is rarely pale. In the Columbia a few with pale flesh are sometimes taken in spring, and an increasing number from July on. In Frazer River the fall run of the quinnat is nearly worthless for canning purposes, because so many are "white-meated." In the spring very few are "white-meated"; but the number increases towards fall, when there is every variation, some having red streaks running through them, others being red toward the head and pale toward the tail. The red and pale ones cannot be distinguished externally, and the color is dependent on neither age nor sex. There is said to be no difference in the taste, but there is little market for canned salmon not of the conventional orange-color.

As the season advances the difference between the males and females becomes more and more marked, and keeps pace with the development of the milt, as is shown by dissection. The males have (1) the premaxillaries and the tip of the lower jaw more and more prolonged, both of the jaws becoming finally

strongly and often extravagantly hooked, so that either they shut by the side of each other like shears, or else the mouth cannot be closed. (2) The front teeth become very long and canine-like, their growth proceeding very rapidly, until they are often half an inch long. (3) The teeth on the vomer and tongue often disappear. (4) The body grows more compressed and deeper at the shoulders, so that a very distinct hump is formed; this is more developed in the humpback salmon, but is found in all. (5) The scales disappear, especially on the back, by the growth of spongy skin. (6) The color changes from silvery to various shades of black and red, or blotchy, according to the species. The blue-back turns rosy-red, the head bright olive; the dog-salmon a dull red with blackish bars, and the quinnat generally blackish. The distorted males are

Fig. 60.—Quinnat Salmon, *Oncorhynchus tschawytscha* (Walbaum). Monterey Bay. (Photograph by C. Rutter.)

commonly considered worthless, rejected by the canners and salmon-salters, but preserved by the Indians. These changes are due solely to influences connected with the growth of the reproductive organs. They are not in any way due to the action of fresh water. They take place at about the same time in the adult males of all species, whether in the ocean or in the rivers. At the time of the spring runs all are symmetrical. In the fall all males, of whatever species, are more or less distorted. Among the dog-salmon, which run only in the fall, the males are hook-jawed and red-blotched when they first enter the Strait of Fuca from the outside. The humpback, taken in salt water about Seattle, have the same peculiarities. The male is slab-sided, hook-billed, and distorted, and is re-

jected by the canners. No hook-jawed females of any species have been seen.

On first entering a stream the salmon swim about as if playing. They always head towards the current, and this appearance of playing may be simply due to facing the moving tide. Afterwards they enter the deepest parts of the stream and swim straight up, with few interruptions. Their rate of travel at Sacramento is estimated by Stone at about two miles per day; on the Columbia at about three miles per day. Those which enter the Columbia in the spring and ascend to the mountain rivers of Idaho must go at a more rapid rate than this, as they must make an average of nearly four miles per day.

As already stated, the economic value of any species depends in great part on its being a "spring salmon." It is not generally possible to capture salmon of any species in large numbers until they have entered the estuaries or rivers, and the spring salmon enter the large rivers long before the growth of the organs of reproduction has reduced the richness of the flesh. The fall salmon cannot be taken in quantity until their flesh has deteriorated; hence the dog-salmon is practically almost worthless except to the Indians, and the humpback salmon was regarded as little better until comparatively recently, when it has been placed on the market in cans as "Pink Salmon." It sells for about half the price of the red salmon and one-third that of the quinnat. The red salmon is smaller than the quinnat but, outside the Sacramento and the Columbia, far more abundant, and at present it exceeds the quinnat in economic value. The pack of red salmon in Alaska amounted in 1902 to over two million cases (48 pounds each), worth wholesale about $4.00 per case, or about $8,000,000. The other species in Alaska yield about one million cases, the total wholesale value of the pack for 1902 being $8,667,673. The aggregate value of the quinnat is considerably less, but either species far exceed in value all other fishes of the Pacific taken together. The silver salmon is found in the inland waters of Puget Sound for a considerable time before the fall rains cause the fall runs, and it may be taken in large numbers with seines before the season for entering the rivers.

The fall salmon of all species, but especially of the dog-

salmon, ascend streams but a short distance before spawning. They seem to be in great anxiety to find fresh water, and many of them work their way up little brooks only a few inches deep, where they perish miserably, floundering about on the stones. Every stream of whatever kind, from San Francisco to Bering Sea, has more or less of these fall salmon.

The absence of the fine spring salmon in the streams of Japan is the cause of the relative unimportance of the river fisheries of the northern island of Japan, Hokkaido. It is not likely that either the quinnat or the red salmon can be introduced into these rivers, as they have no snow-fed streams, and few of them pass through lakes which are not shut off by waterfalls. For the same reason neither of these species is likely to become naturalized in the waters of our Eastern States, though it is worth while to bring the red salmon to the St. Lawrence. The silver salmon, already abundant in Japan, should thrive in the rivers and bays of New England.

The Parent-stream Theory. — It has been generally accepted as unquestioned by packers and fishermen that salmon return to spawn to the very stream in which they were hatched. As early as 1880 the present writer placed on record his opinion that this theory was unsound. In a general way most salmon return to the parent stream, because when in the sea the parent stream is the one most easily reached. The channels and runways which directed their course to the sea may influence their return trip in the same fashion. When the salmon is mature it seeks fresh water. Other things being equal, about the same number will run each year in the same channel. With all this, we find some curious facts. Certain streams will have a run of exceptionally large or exceptionally small red salmon. The time of the run bears some relation to the length of the stream: those who have farthest to go start earliest. The time of running bears also a relation to the temperature of the spawning grounds: where the waters cool off earliest the fish run soonest.

The supposed evidence in favor of the parent-stream theory may be considered under three heads: * (1) Distinctive runs in

* See an excellent article by H. S. Davis in the *Pacific Fisherman* for July, 1903.

various streams. (2) Return of marked salmon. (3) Introduction of salmon into new streams followed by their return.

Under the first head it is often asserted of fishermen that they can distinguish the salmon of different streams. Thus the Lynn Canal red salmon are larger than those in most waters, and it is claimed that those of Chilcoot Inlet are larger than those of the sister stream at Chilcat. The red salmon of Red Fish Bay on Baranof Island are said to be much smaller than usual, and those of the neighboring Necker Bay are not more than one-third the ordinary size. Those of a small rapid stream near Nass River are more wiry than those of the neighboring large stream. The same claim is made for the different streams of Puget Sound, each one having its characteristic run. In all this there is some truth and perhaps some exaggeration. I have noticed that the Chilcoot fish seem deeper in body than those at Chilcat. The red salmon becomes compressed before spawning, and the Chilcoot fishes having a short run spawn earlier than the Chilcat fishes, which have many miles to go, the water being perhaps warmer at the mouth of the river. Perhaps some localities may meet the nervous reactions of small fishes, while not attracting the large ones. Mr. H. S. Davis well observes that "until a constant difference has been demonstrated by a careful examination of large numbers of fish from each stream taken *at the same time*, but little weight can be attached to arguments of this nature."

It is doubtless true as a general proposition that nearly all salmon return to the region in which they were spawned. Most of them apparently never go far away from the mouth of the stream or the bay into which it flows. It is true that salmon are occasionally taken well out at sea, and it is certain that the red-salmon runs of Puget Sound come from outside the Straits of Fuca. There is, however, evidence that they rarely go so far as that. When seeking shore they do not reach the original channels.

In 1880 the writer, studying the salmon of the Columbia, used the following words, which he has not had occasion to change:

"It is the prevailing impression that the salmon have some special instinct which leads them to return to spawn in the

same spawning grounds where they were originally hatched. We fail to find any evidence of this in the case of the Pacific-coast salmon, and we do not believe it to be true. It seems more probable that the young salmon hatched in any river mostly remain in the ocean within a radius of twenty, thirty, or forty miles of its mouth. These, in their movements about in the ocean, may come into contact with the cold waters of their parent rivers, or perhaps of any other river, at a considerable distance from the shore. In the case of the quinnat and the blue-back their 'instinct' seems to lead them to ascend these fresh waters, and in a majority of cases these waters will be those in which the fishes in question were originally spawned. Later in the season the growth of the reproductive organs leads them to approach the shore and search for fresh waters, and still the chances are that they may find the original stream. But undoubtedly many fall salmon ascend, or try to ascend, streams in which no salmon was ever hatched. In little brooks about Puget Sound, where the water is not three inches deep, are often found dead or dying salmon which have entered them for the purpose of spawning. It is said of the Russian River and other California rivers that their mouths, in the time of low water in summer, generally become entirely closed by sand-bars, and that the salmon, in their eagerness to ascend them, frequently fling themselves entirely out of water on the beach. But this does not prove that the salmon are guided by a marvelous geographical instinct which leads them to their parent river in spite of the fact that the river cannot be found. The waters of Russian River soak through these sand-bars, and the salmon instinct, we think, leads them merely to search for fresh waters. This matter is much in need of further investigation; at present, however, we find no reason to believe that the salmon enter the Rogue River simply because they were spawned there, or that a salmon hatched in the Clackamas River is more likely, on that account, to return to the Clackamas than to go up the Cowlitz or the Des Chûtes."

Attempts have been made to settle this question by marking the fry. But this is a very difficult matter indeed. Almost the only structure which can be safely mutilated is the adipose fin, and this is often nipped off by sticklebacks and other med-

dling fish. The following experiments have been tried, according to Mr. Davis:

In March, 1896, 5000 king-salmon fry were marked by cutting off the adipose fin, then set free in the Clackamas River. Nearly 400 of these marked fish are said to have been taken in the Columbia in 1898, and a few more in 1899. In addition a few were taken in 1898, 1899, and 1900 in the Sacramento River, but in much less numbers than in the Columbia. In the Columbia most were taken at the mouth of the river, where nearly all of the fishing was done, but a few were in the original stream, the Clackamas. It is stated that the fry thus set free in the Clackamas came from eggs obtained in the Sacramento—a matter which has, however, no bearing on the present case.

In the Kalama hatchery on the Columbia River, Washington, 2000 fry of the quinnat or king-salmon were marked in 1899 by a V-shaped notch in the caudal fin. Numerous fishes thus marked were taken in the lower Columbia in 1901 and 1902. A few were taken at the Kalama hatchery, but some also at the hatcheries on Wind River and Clackamas River. At the hatchery on Chehalis River six or seven were taken, the stream not being a tributary of the Columbia, but flowing into Shoalwater Bay. None were noticed in the Sacramento. The evidence shows that the most who are hatched in a large stream tend to return to it, and that in general most salmon return to the parent region. There is no evidence that a salmon hatched in one branch of a river tends to return there rather than to any other. Experiments of Messrs. Rutter and Spaulding in marking adult fish at Karluk would indicate that they roam rather widely about the island before spawning. An adult spawning fish, marked and set free at Karluk, was taken soon after on the opposite side of the island of Kadiak.

The introduction of salmon into new streams may throw some light on this question. In 1897 and 1898 3,000,000 young quinnat-salmon fry were set free in Papermill Creek near Olema, California. This is a small stream flowing into the head of Tomales Bay, and it had never previously had a run of salmon. In 1900, and especially in 1901, large quinnat salmon appeared in considerable numbers in this stream. One specimen weighing about sixteen pounds was sent to the present writer for

identification. These fishes certainly returned to the parent stream, although this stream was one not at all fitted for their purpose.

But this may be accounted for by the topography of the bay. Tomales Bay is a long and narrow channel, about twenty miles long and from one to five in width, isolated from other rivers and with but one tributary stream. Probably the salmon had not wandered far from it; some may not have left it at all. In any event, a large number certainly came back to the same place.

That the salmon rarely go far away is fairly attested. Schools of king-salmon play in Monterey Bay, and chase the herring about in the channels of southeastern Alaska. A few years since Captain J. F. Moser, in charge of the *Albatross*, set gill-nets for salmon at various places in the sea off the Oregon and Washington coast, catching none except in the bays.

Mr. Davis gives an account of the liberation of salmon in Chinook River, which flows into the Columbia at Baker's Bay:

"It is a small, sluggish stream and has never been frequented by Chinook salmon, although considerable numbers of silver and dog salmon enter it late in the fall. A few years ago the State established a hatchery on this stream, and since 1898 between 1,000,000 and 2,000,000 Chinook fry have been turned out here annually. The fish are taken from the pound-nets in Baker's Bay, towed into the river in crates and then liberated above the dike, which prevents their return to the Columbia. When ripe the salmon ascend to the hatchery, some two or three miles farther up the river, where they are spawned.

"The superintendent of the hatchery, Mr. Hansen, informs me that in 1902, during November and December, quite a number of Chinook salmon ascended the Chinook River. About 150 salmon of both sexes were taken in a trap located in the river about four miles from its mouth. At first thought it would appear that these were probably fish which, when fry, had been liberated in the river, but unfortunately there is no proof that this was the case. According to Mr. Hansen, the season of 1902 was remarkable in that the salmon ran inshore in large schools, a thing which they had not done before for years. It

is possible that the fish, being forced in close to the shore, came in contact with the current from the Chinook River, which, since the stream is small and sluggish, would not be felt far from shore. Once brought under the influence of the current from the river, the salmon would naturally ascend that stream, whether they had been hatched there or not."

The general conclusion, apparently warranted by the facts at hand, is that salmon, for the most part, do not go to a great distance from the stream in which they are hatched, that most of them return to the streams of the same region, a majority to the parent stream, but that there is no evidence that they choose the parental spawning grounds in preference to any other, and none that they will prefer an undesirable stream to a favorable one for the reason that they happen to have been hatched in the former.

The Jadgeska Hatchery.—Mr. John C. Callbreath of Wrangel, Alaska, has long conducted a very interesting but very costly experiment in this line. About 1890 he established himself in a small stream called Jadgeska on the west coast of Etolin Island, tributary to McHenry Inlet, Clarence Straits. This stream led from a lake, and in it a few thousand red salmon spawned, besides multitudes of silver salmon, dog-salmon, and humpback salmon. Making a dam across the stream, he helped the red salmon over it, destroying all of the inferior kinds which entered the stream. He also established a hatchery for the red salmon, turning loose many fry yearly for ten or twelve years. This was done in the expectation that all the salmon hatched would return to Jadgeska in about four years. By destroying all individuals of other species attempting to run, it was expected that they would become extinct so far as the stream is concerned.

The result of this experiment has been disappointment. After twelve years or more there has been no increase of red salmon in the stream, and no decrease of humpbacks and other humbler forms of salmon. Mr. Callbreath draws the conclusion that salmon run at a much greater age than has been supposed—at the age of sixteen years, perhaps, instead of four. A far more probable conclusion is that his salmon have joined other bands bound for more suitable streams. It is indeed

claimed that since the establishment of Callbreath's hatchery on Etolin Island there has been a notable increase of the salmon run in the various streams of Prince of Wales Island on the opposite side of Clarence Straits. But this statement, while largely current among the cannerymen, and not improbable, needs verification.

We shall await with much interest the return of the thousands of salmon hatched in 1902 in Naha stream. We may venture the prophecy that while a large percentage will return to Loring, many others will enter Yes Bay, Karta Bay, Moira Sound, and other red-salmon waters along the line of their return from Dixon Entrance or the open sea.

Salmon-packing.—The canning of salmon, that is, the packing of the flesh in tin cases, hermetically sealed after boiling, was begun on the Columbia River by the Hume Brothers in 1866. In 1874 canneries were established on the Sacramento River, in 1876 on Puget Sound and on Frazer River, and in 1878 in Alaska. At first only the quinnat salmon was packed; afterwards the red salmon and the silver salmon, and finally the humpback, known commercially as pink salmon. In most cases the flesh is packed in one-pound tins, forty-eight of which constitute a case. The wholesale price in 1903 was for quinnat salmon $5.60 per case, red salmon $4.00, silver salmon $2.60, humpback salmon $2.00, and dog-salmon $1.50. It costs in round numbers $2.00 to pack a case of salmon. The very low price of the inferior brands is due to overproduction.

The output of the salmon fishery of the Pacific coast amounts to about fifteen millions per year, that of Alaska constituting seven to nine millions of this amount. Of this amount the red salmon constitutes somewhat more than half, the quinnat about four-fifths of the rest.

In almost all salmon streams there is evidence of considerable diminution in numbers, although the evidence is sometimes conflicting. In Alaska this has been due to the vicious custom, now done away with, of barricading the streams so that the fish could not reach the spawning grounds, but might be all taken with the net. In the Columbia River the reduction in numbers is mainly due to stationary traps and salmon-wheels, which leave the fish relatively little chance to reach the

spawning grounds. In years of high water doubtless many salmon run in the spring which might otherwise have waited until fall.

The key to the situation lies in the artificial propagation of salmon by means of well-ordered hatcheries. By this means the fisheries of the Sacramento have been fully restored, those of the Columbia approximately maintained, and a hopeful beginning has been made in hatching red salmon in Alaska.

CHAPTER V

SALMONIDÆ—(*Continued*)

S**ALMO, the Trout and Atlantic Salmon.**—The genus *Salmo* comprises those forms of salmon which have been longest known. As in related genera, the mouth is large, and the jaws, palatines, and tongue are armed with strong teeth. The vomer is flat, its shaft not depressed below the level of the head or chevron (the anterior end). There are a few teeth on the chevron; and behind it, on the shaft, there is either a double series of teeth or an irregular single series. These teeth in the true salmon disappear with age, but in the others (the black-spotted trout) they are persistent. The scales are silvery and moderate or small in size. There are 9 to 11 developed rays in the anal fin. The caudal fin is truncate, or variously concave or forked. There are usually 40 to 70 pyloric cœca, 11 or 12 branchiostegals, and about 20 $(8+12)$ gill-rakers. The sexual peculiarities are in general less marked than in *Oncorhynchus;* they are also greater in the anadromous species than in those which inhabit fresh waters. In general the male in the breeding season is redder, its jaws are prolonged, the front teeth enlarged, the lower jaw turned upwards at the end, and the upper jaw notched, or sometimes even perforated, by the tip of the lower. All the species of *Salmo* (like those of *Oncorhynchus*) are more or less spotted with black. Unlike the species of *Oncorhynchus*, the species of *Salmo* feed more or less while in fresh water, and the individuals for the most part do not die after spawning, although many old males do thus perish.

The Atlantic Salmon.—The large species of *Salmo*, called salmon by English-speaking people (*Salmo salar*, *Salmo trutta*), are marine and anadromous, taking the place in the North Atlantic occupied in the North Pacific by the species of *Onco-*

rhynchus. Two others more or less similar in character occur in Japan and Kamchatka. The others (trout), forming the subgenus *Salar*, are non-migratory, or at least irregularly or imperfectly anadromous. The true or black-spotted trout abound in all streams of northern Europe, northern Asia, and in that part of North America which lies *west* of the Mississippi Valley. The black-spotted trout are entirely wanting in eastern America—a remarkable fact in geographical distribution, perhaps explained only on the hypothesis of the comparatively recent and Eurasiatic origin of the group, which, we may suppose, has not yet had opportunity to extend its range across the plains, unsuitable for salmon life, which separate the upper Missouri from the Great Lakes.

The salmon (*Salmo salar*) is the only black-spotted salmonoid found in American waters tributary to the Atlantic. In Europe, where other species similarly colored occur, the species may be best distinguished by the fact that the teeth on the shaft of the vomer mostly disappear with age. From the only other species positively known, the salmon trout (*Salmo trutta*), which shares this character, the true salmon may be distinguished by the presence of but eleven scales between the adipose fin and the lateral line, while *Salmo trutta* has about fourteen. The scales are comparatively large in the salmon, there being about one hundred and twenty-five in the lateral line. The caudal fin, which is forked in the young, becomes, as in other species of salmon, more or less truncate with age. The pyloric cœca are fifty to sixty in number.

The color in adults, according to Dr. Day, is "superiorly of a steel-blue, becoming lighter on the sides and beneath. Mostly a few rounded or X-shaped spots scattered above the lateral line and upper half of the head, being more numerous in the female than in the male. Dorsal, caudal, and pectoral fins dusky; ventrals and anal white, the former grayish internally. Prior to entering fresh waters these fish are of a brilliant steel-blue along the back, which becomes changed to a muddy tinge when they enter rivers. After these fish have passed into the fresh waters for the purpose of breeding, numerous orange streaks appear in the cheeks of the male, and also spots or even marks of the same, and likewise of a red color, on the body.

It is now termed a 'redfish.' The female, however, is dark in color and known as 'blackfish.' 'Smolts' (young river fish) are bluish along the upper half of the body, silvery along the sides, due to a layer of silvery scales being formed over the trout-like colors, while they have darker fins than the yearling 'ping,' but similar bands and spots, which can be seen (as in the parr) if the example be held in certain positions of light. 'Parr' (fishes of the year) have two or three black spots only on the opercle, and black spots and also orange ones along the upper half of the body, and no dark ones below the lateral line, although there may be orange ones which can be seen in its course. Along the side of the body are a series (12 to 15) of transverse bluish bands, wider than the ground color and crossing the lateral line, while in the upper half of the body the darker color of the back forms an arch over each of these bands, a row of spots along the middle of the rayed dorsal fin, and the adipose orange-tipped."

The dusky cross-shades found in the young salmon or parr are characteristic of the young of salmon, trout, grayling, and nearly all the other *Salmonidæ*.

The salmon of the Atlantic is, as already stated, an anadromous fish, spending most of its life in the sea, and entering the streams in the fall for the purpose of reproduction. The time of running varies much in different streams and also in different countries. As with the Pacific species, these salmon are not easily discouraged in their progress, leaping cascades and other obstructions, or, if these prove impassable, dying after repeated fruitless attempts.

The young salmon, known as the "parr," is hatched in the spring. It usually remains about two years in the rivers, descending at about the third spring to the sea, when it is known as "smolt." In the sea it grows much more rapidly, and becomes more silvery in color, and is known as "grilse." The grilse rapidly develop into the adult salmon; and some of them, as in the case with the grilse of the Pacific salmon, are capable of reproduction.

After spawning the salmon are very lean and unwholesome in appearance, as in fact. They are then known as "kelts." The Atlantic salmon does not ascend rivers to any such dis-

tances as those traversed by the quinnat and the blue-back. Its kelts, therefore, for the most part survive the act of spawning. Dr. Day thinks that they feed upon the young salmon in the rivers, and that, therefore, the destruction of the kelts might increase the supply of salmon.

As a food-fish the Atlantic salmon is very similar to the quinnat salmon, neither better nor worse, so far as I can see, when equally fresh. In both the flesh is rich and finely flavored; but the appetite of man becomes cloyed with salmon-flesh sooner than with that of whitefish, smelt, or charr. In size the Atlantic salmon does not fall far short of the quinnat. The average weight of the adult is probably less than fifteen pounds. The largest one of which I find a record was taken on the coast of Ireland in 1881, and weighed $84\frac{3}{4}$ pounds.

The salmon is found in Europe between the latitude of 45° and 75°. In the United States it is now rarely seen south of Cape Cod, although formerly the Hudson and numerous other rivers were salmon-streams. Overfishing, obstructions in the rivers, and pollution of the water by manufactories and by city sewage are agencies against which the salmon cannot cope.

Seven species of salmon (as distinguished from trout) are recognized by Dr. Günther in Europe, and three in America. The landlocked forms, abundant in Norway, Sweden, and Maine, which cannot, or at least do not, descend to the sea, are regarded by him as distinct species. "The question," observes Dr Günther, "whether any of the migratory species can be retained by artificial means in fresh water, and finally accommodate themselves to a permanent sojourn therein, must be negatived for the present." On this point I think that the balance of evidence leads to a different conclusion. These fresh-water forms (*Sebago* and *Ouananiche*) are actually salmon which have become landlocked. I have compared numerous specimens of the common landlocked salmon (*Salmo salar sebago*) of the lakes of Maine and New Brunswick with landlocked salmon (*Salmo salar hardini*) from the lakes of Sweden, and with numerous migratory salmon, both from America and Europe. I see no reason for regarding them as specifically distinct. The differences are very trivial in kind, and not greater than would be expected on the hypothesis of recent

adaptation of the salmon to lake life. We have therefore on our Atlantic coast but one species of salmon, *Salmo salar*. The landlocked form of the lakes of Maine is *Salmo salar sebago*. The *Ouananiche* of Lake St. John and the Saguenay, beloved of anglers, is *Salmo salar ouananiche*.

The Ouananiche.—Dr. Henry Van Dyke writes thus of the *Ouananiche:* "But the prince of the pool was the fighting *Ouananiche*, the little salmon of St. John. Here let me chant thy praise, thou noblest and most high-minded fish, the cleanest feeder, the merriest liver, the loftiest leaper, and the bravest warrior of all creatures that swim! Thy cousin, the trout, in his purple and gold with crimson spots, wears a more splendid armor than thy russet and silver mottled with black, but thine is the kinglier nature.

"The old salmon of the sea who begat thee long ago in these inland waters became a backslider, descending again to the ocean, and grew gross and heavy with coarse feeding. But thou, unsalted salmon of the foaming floods, not landlocked as men call thee, but choosing of thine own free will to dwell on a loftier level in the pure, swift current of a living stream, hath grown in grace and risen to a better life.

"Thou art not to be measured by quantity but by quality, and thy five pounds of pure vigor will outweigh a score of pounds of flesh less vitalized by spirit. Thou feedest on the flies of the air, and thy food is transformed into an aerial passion for flight, as thou springest across the pool, vaulting toward the sky. Thine eyes have grown large and keen by piercing through the foam, and the feathered hook that can deceive thee must be deftly tied and delicately cast. Thy tail and fins, by ceaseless conflict with the rapids, have broadened and strengthened, so that they can flash thy slender body like a living arrow up the fall. As Launcelot among the knights, so art thou among the fish, the plain-armored hero, the sunburnt champion of all the water-folk."

Dr. Francis Day, who has very thoroughly studied these fishes, takes, in his memoir on "The Fishes of Great Britain and Ireland," and in other papers, a similar view in regard to the European species. Omitting the species with permanent teeth on the shaft of the vomer (subgenus *Salar*), he finds

among the salmon proper only two species, *Salmo salar* and *Salmo trutta.* The latter species, the sea-trout or salmon-trout of England and the estuaries of northern Europe, is similar to the salmon in many respects, but has rather smaller scales, there being fourteen in an oblique series between the adipose fin and the lateral line. It is not so strong a fish as the salmon, nor does it reach so large a size. Although naturally anadromous, like the true salmon, landlocked forms of the salmon-trout are not uncommon. These have been usually regarded as different species, while aberrant or intermediate individuals are usually regarded as hybrids. The salmon-trout of Europe have many analogies with the steelhead of the Pacific.

The present writer has examined many thousands of American *Salmonidæ*, both of *Oncorhynchus* and *Salmo.* While many variations have come to his attention, and he has been compelled more than once to modify his views as to specific distinctions, he has never yet seen an individual which he had the slightest reason to regard as a "hybrid." It is certainly illogical to conclude that every specimen which does not correspond to our closet-formed definition of its species must therefore be a "hybrid" with some other. There is no evidence worth mentioning, known to me, of extensive hybridization in a state of nature in any group of fishes. This matter is much in need of further study; for what is true of the species in one region, in this regard, may not be true of others. Dr. Günther observes:

"Johnson, a correspondent of Willughby, had already expressed his belief that the different salmonoids interbreed; and this view has since been shared by many who have observed these fishes in nature. Hybrids between the sewin (*Salmo trutta cambricus*) and the river-trout (*Salmo fario*) were numerous in the Rhymney and other rivers of South Wales before salmonoids were almost exterminated by the pollutions allowed to pass into these streams, and so variable in their characters that the passage from one species to the other could be demonstrated in an almost unbroken series, which might induce some naturalists to regard both species as identical. Abundant evidence of a similar character has accumulated, showing the frequent occurrence of hybrids between *Salmo fario* and *S. trutta.* . . . In some rivers the conditions appear

to be more favorable to hybridism than in others in which hybrids are of comparatively rare occurrence. Hybrids between the salmon and other species are very scarce everywhere."

Very similar to the European *Salmo trutta* is the trout of Japan (*Salmo perryi*), the young called yamabe, the adult kawamasu, or river-salmon. This species abounds everywhere in Japan, the young being the common trout of the brooks, black-spotted and crossed by parr-marks, the adult reaching a weight of ten or twelve pounds in the larger rivers and descending to the sea. In Kamchatka is another large, black-spotted, salmon-like species properly to be called a salmon-trout. This is *Salmo mykiss*, a name very wrongly applied to the cutthroat trout of the Columbia.

The black-spotted trout, forming the subgenus *Salar*, differ from *Salmo salar* and *Salmo trutta* in the greater development of the vomerine teeth, which are persistent throughout life, in a long double series on the shaft of the vomer. About seven species are laboriously distinguished by Dr. Günther in the waters of western Europe. Most of these are regarded by Dr. Day as varieties of *Salmo fario*. The latter species, the common river-trout or lake-trout of Europe, is found throughout northern and central Europe, wherever suitable waters occur. It is abundant, gamy, takes the hook readily, and is excellent as food. It is more hardy than the different species of charr, although from an æsthetic point of view it must be regarded as inferior to all of the *Salvelini*. The largest river-trout recorded by Dr. Day weighed twenty-one pounds. Such large individuals are usually found in lakes in the north, well stocked with smaller fishes on which trout may feed. Farther south, where the surroundings are less favorable to trout-life, they become mature at a length of less than a foot, and a weight of a few ounces. These excessive variations in the size of individuals have received too little notice from students of *Salmonidæ*. Similar variations occur in all the non-migratory species of *Salmo* and of *Salvelinus*. Numerous river-trout have been recorded from northern Asia, but as yet nothing can be definitely stated as to the number of species actually existing.

The Black-spotted Trout.—In North America only the region west of the Mississippi Valley, the streams of southeastern

Alaska, and the valley of Mackenzie River have species of black-spotted trout. There are few of these north of Sitka in Alaska, although black-spotted trout are occasionally taken on Kadiak and about Bristol Bay, and none east of the Rocky Mountain region. If we are to follow the usage of the names "salmon" and "trout" which prevails in England, we should say that, in America, it is only these western regions which have any trout at all. Of the number of species (about twenty-five in all) which have been indicated by authors, certainly not more than about 8 to 10 can possibly be regarded as distinct species. The other names are either useless synonyms, or else they have been applied to local varieties which pass by degrees into the ordinary types.

The Trout of Western America.—In the western part of America are found more than a score of forms of trout of the genus *Salmo*, all closely related and difficult to distinguish. There are representatives in the headwaters of the Rio Grande, Arkansas, South Platte, Missouri, and Colorado rivers; also in the Great Salt Lake basin, throughout the Columbia basin, in all suitable waters from southern California and Chihuahua to Sitka, and even to Bristol Bay, similar forms again appearing in Kamchatka and Japan.

Among the various more or less tangible species that may be recognized, three distinct series appear. These have been termed the cutthroat-trout series (allies of *Salmo clarkii*), the rainbow-trout series (allies of *Salmo irideus*), and the steelhead series (allies of *Salmo rivularis*, a species more usually but wrongly called *Salmo gairdneri*).

The steelhead, or *rivularis* series, is found in the coastwise streams of California and in the streams of Oregon and Washington, below the great Shoshone Falls of Snake River, and northward in Alaska along the mainland as far as Skaguay. The steelhead-trout reach a large size (10 to 20 pounds). They spend a large part of their life in the sea. In all the true steelheads the head is relatively very short, its length being contained about five times in the distance from tip of snout to base of caudal fin. The scales in the steelhead are always rather small, about 150 in a linear series, and there is no red under the throat. The spots on the dorsal fin are fewer in the steelhead (4 to 6 rows) than in the other American trout.

The rainbow forms are chiefly confined to the streams of California and Oregon. In these the scales are large (about 135 in a lengthwise series) and the head is relatively large, forming nearly one-fourth of the length to base of caudal. These enter the sea only when in the small coastwise streams. Usually they have no red under the throat. The cutthroat forms are found from Humboldt Bay northward as far as Sitka, in the coastwise streams of northern California, Oregon, Washington, and Alaska, and all the clear streams on both sides of the Rocky Mountains, and in the Great Basin and the headwaters of the Colorado. The cutthroat-trout have the scales small, about 180, and there is always a bright dash of orange-red on each side concealed beneath the branches of the lower jaw. Along the western slope of the Sierra Nevada there are also forms of trout with the general appearance of rainbow-trout and evidently belonging to that species, but with scales intermediate in number (in McCloud River), var. *shasta*, or with scales as small as in the typical cutthroat (Kern River), var. *gilberti*. In these small-scaled forms more or less red appears below the lower jaw, and they are doubtless what they appear to be, really intermediate between *clarkii* and *irideus*, although certainly nearest the latter. A similar series of forms occurs in the Columbia basin, the upper Snake being inhabited by *clarkii* and the lower Snake by *clarkii* and *rivularis*, together with a medley of forms apparently intermediate.

It seems probable that the American trout originated in Asia, extended its range to southeast Alaska, thence southward to the Fraser and Columbia, thence to the Yellowstone and the Missouri *via* Two-Ocean Pass; from the Snake River to the Great Basins of Utah and Nevada; from the Missouri southward to the Platte and the Arkansas, thence from the Platte to the Rio Grande and the Colorado, and then from Oregon southward coastwise and along the Sierras to northern Mexico, thence northward and coastwise, the sea-running forms passing from stream to stream.

Of the American species the rainbow trout of California (*Salmo irideus*) most nearly approaches the European *Salmo fario*. It has the scales comparatively large, although rather smaller than in *Salmo fario*, the usual number in a longitudinal

series being about 135. The mouth is smaller than in other American trout; the maxillary, except in old males, rarely extending beyond the eye. The caudal fin is well forked, becoming in very old fishes more nearly truncate. The head is relatively large, about four times in the total length. The size of the head forms the best distinctive character. The color, as in all the other species, is bluish, the sides silvery in the males, with a red lateral band, and reddish and dusky blotches. The head, back, and upper fins are sprinkled with round black spots, which are very variable in number, those on the dorsal usually in about nine rows. In specimens taken

Fig. 61.—Rainbow Trout (male), *Salmo irideus shasta* Jordan. (Photograph by Cloudsley Rutter.)

in the sea this species, like most other trout in similar conditions, is bright silvery, and sometimes immaculate. This species is especially characteristic of the waters of California. It abounds in every clear brook, from the Mexican line northward to Mount Shasta, or beyond, the species passing in the Columbia region by degrees into the species or form known as *Salmo masoni*, the Oregon rainbow trout, a small rainbow trout common in the forest streams of Oregon, with smaller mouth and fewer spots on the dorsal. No true rainbow trout have been anywhere obtained to the eastward of the Cascade Range or of the Sierra Nevada, except as artificially planted in the Truckee River. The species varies much in size; specimens from northern California often reach a weight of six pounds, while in the streams above Tia Juana in Lower California the south-

ernmost locality from which I have obtained trout, they seldom exceed a length of six inches. Although not usually an anadromous species, the rainbow trout frequently moves about in the rivers, and it often enters the sea, large sea-run specimens being often taken for steelheads. Several attempts have been made to introduce it in Eastern streams, but it appears to seek the sea when it is lost. It is apparently more hardy and less greedy than the American charr, or brook-trout (*Salvelinus*

FIG. 62.—Rainbow Trout (female), *Salmo irideus shasta* Jordan. (Photograph by Cloudsley Rutter.)

fontinalis). On the other hand, it is distinctly inferior to the latter in beauty and in gaminess.

Three varieties of some importance have been indicated, *Salmo irideus stonei*, the Nissui trout of the Klamath, with spots on the posterior parts only, *Salmo irideus shasta* of the upper Sacramento, and the small-scaled *Salmo irideus gilberti* of the Kings and Kern rivers. In the head-waters of the Kern, in a stream called Volcano Creek or Whitney Creek, the waterfall sometimes called Agua-Bonita shuts off the movements of the trout. Above this fall is a dwarf form with bright golden fins, and the scales scarcely imbricated. This is the "golden trout of Mount Whitney," *Salmo irideus agua-bonita*. It will possibly be found to change back to the original type if propagated in different waters.

In beauty of color, gracefulness of form and movement,

sprightliness when in the water, reckless dash with which it springs from the water to meet the descending fly ere it strikes the surface, and the mad and repeated leaps from the water when hooked, the rainbow trout must ever hold a very high rank. "The gamest fish we have ever seen," writes Dr. Evermann, "was a 16-inch rainbow taken on a fly in a small spring branch tributary of Williamson River in southern Oregon. It was in a broad and deep pool of exceedingly clear water. As the angler from behind a clump of willows made the cast the trout bounded from the water and met the fly in the air a foot or more above the surface; missing it, he dropped upon the water, only to turn about and strike viciously a second time at the fly just as it touched the surface; though he again missed the fly, the hook caught him in the lower jaw from the outside, and then began a fight which would delight the heart of any angler. His first effort was to reach the bottom of the pool, then, doubling upon the line, he made three jumps from the water in quick succession, clearing the surface in each instance from one to four feet, and every time doing his utmost to free himself from the hook by shaking his head as vigorously as a dog shakes a rat. Then he would rush wildly about in the large pool, now attempting to go down over the riffle below the pool, now trying the opposite direction, and often striving to hide under one or the other of the banks. It was easy to handle the fish when the dash was made up or down stream or for the opposite side, but when he turned about and made a rush for the protection of the overhanging bank upon which the angler stood it was not easy to keep the line taut. Movements such as these were frequently repeated, and two more leaps were made. But finally he was worn out after as honest a fight as trout ever made."

"The rainbow takes the fly so readily that there is no reason for resorting to grasshoppers, salmon-eggs, or other bait. It is a fish whose gaminess will satisfy the most exacting of expert anglers and whose readiness to take any proper line will please the most impatient of inexperienced amateurs."

The steelhead (*Salmo rivularis*) is a large trout, reaching twelve to twenty pounds in weight, found abundantly in river estuaries and sometimes in lakes from Lynn Canal to Santa

Barbara. The spent fish abound in the rivers in spring at the time of the salmon-run. The species is rarely canned, but is valued for shipment in cold storage. Its bones are much more firm than those of the salmon—a trait unfavorable for canning purposes. The flesh when not spent after spawning is excellent. The steelhead does not die after spawning, as all the Pacific salmon do.

It is thought by some anglers that the young fish hatched in the brooks from eggs of the steelhead remain in mountain streams from six to thirty-six months, going down to the sea with the high waters of spring, after which they return to spawn as typical steelhead trout. I now regard this view as unfounded. In my experience the rainbow and the steelhead are always distinguishable: the steelhead abounds where the rain-

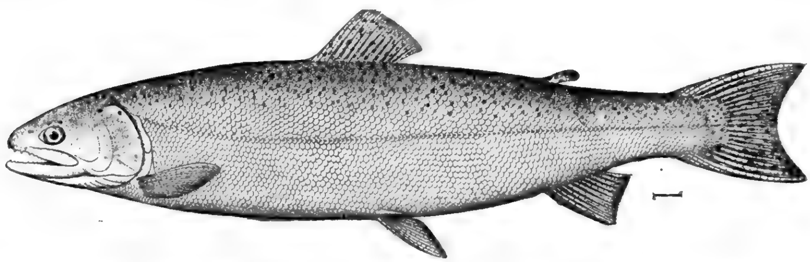


FIG. 63.—Steelhead Trout, *Salmo rivularis* Ayres. Columbia River.

bow trout is unknown; the scales in the steelhead are always smaller (about 155) than in typical rainbow trout; finally, the small size of the head in the steelhead is always distinctive.

The Kamloops trout, described by the writer from the upper Columbia, seems to be a typical steelhead as found well up the rivers away from the sea. Derived from the steelhead, but apparently quite distinct from it, are three very noble trout, all confined so far as yet known to Lake Crescent in northwestern Washington. These are the crescent trout, *Salmo crescentis*, the Beardslee trout, *Salmo beardsleei*, and the long-headed trout, *Salmo bathœcetor*. The first two, discovered by Admiral L. A. Beardslee, are trout of peculiar attractiveness and excellence. The third is a deep-water form, never rising to the surface, and caught only on set lines. Its origin is still uncertain, and it may be derived from some type other than the steelhead.

Cutthroat or Red-throated Trout. — This species has much smaller scales than the rainbow trout or steelhead, the usual number in a longitudinal series being 160 to 170. Its head is longer (about four times in length to base of caudal). Its mouth is proportionately larger, and there is always a narrow band of small teeth on the hyoid bone at the base of the tongue. These teeth are always wanting in *Salmo irideus* and *rivularis* in which species the rim of the tongue only has teeth. The color in *Salmo clarkii* is, as in other species, exceedingly variable. In life there is always a deep-red blotch on the throat, between the branches of the lower jaw and the membrane connecting them. This is not found in other species, or is reduced to a narrow strip or pinkish shade. It seems to be constant in all varieties of *Salmo clarkii*, at all ages, thus furnishing a good distinctive character. It is the sign manual of the Sioux Indians, and the anglers have already accepted from this mark the name of cutthroat-trout. The cutthroat-trout of some species is found in every suitable river and lake in the great basin of Utah, in the streams of Colorado, Wyoming, and Montana, on both sides of the Rocky Mountains. It is also found throughout Oregon, Washington, Idaho, British Columbia, the coastwise islands of southeastern Alaska (Baranof, etc.), to Kadiak and Bristol Bay, probably no stream or lake suitable for trout-life being without it. In California the species seems to be comparatively rare, and its range rarely extending south of Cape Mendocino. Large sea-run individuals analogous to the steelheads are sometimes found in the mouth of the Sacramento. In Washington and Alaska this species regularly enters the sea. In Puget Sound it is a common fish. These sea-run individuals are more silvery and less spotted than those found in the mountain streams and lakes. The size of *Salmo clarkii* is subject to much variation. Ordinarily four to six pounds is a large size; but in certain favored waters, as Lake Tahoe, and the fjords of southeastern Alaska, specimens from twenty to thirty pounds are occasionally taken.

Those species or individuals dwelling in lakes of considerable size, where the water is of such temperature and depth as insures an ample food-supply, will reach a large size, while those in a restricted environment, where both the water and food are

limited, will be small directly in proportion to these environing restrictions. The trout of the Klamath Lakes, for example, reach a weight of at least 17 pounds, while in Fish Lake in Idaho mature trout do not exceed 8 to $9\frac{1}{4}$ inches in total length or one-fourth pound in weight. In small creeks in the Sawtooth Mountains and elsewhere they reach maturity at a length of 5 or 6 inches, and are often spoken of as brook-trout and with the impression that they are a species different from the larger ones found in the lakes and larger streams. But as all sorts and gradations between these extreme forms may be found in the intervening and connecting waters, the differences are not even of subspecific significance.

Dr. Evermann observes: "The various forms of cutthroat-trout vary greatly in game qualities; even the same subspecies in different waters, in different parts of its habitat, or at different

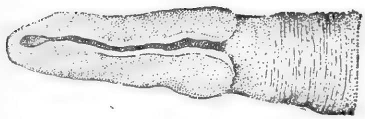


FIG. 64.

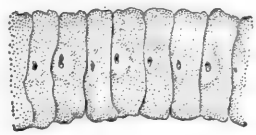


FIG. 65.

FIG. 64.—Head of adult Trout-worm, *Dibothrium cordiceps* Leidy, a parasite of *Salmo clarkii*. From intestine of white pelican, Yellowstone Lake. (After Linton.)
FIG. 65.—Median segments of *Dibothrium cordiceps*.

seasons, will vary greatly in this regard. In general, however, it is perhaps a fair statement to say that the cutthroat-trout are regarded by anglers as being inferior in gaminess to the Eastern brook-trout. But while this is true, it must not by any means be inferred that it is without game qualities, for it is really a fish which possesses those qualities in a very high degree. Its vigor and voraciousness are determined largely, of course, by the character of the stream or lake in which it lives. The individuals which dwell in cold streams about cascades and seething rapids will show marvelous strength and will make a fight which is rarely equaled by its Eastern cousin; while in warmer and larger streams and lakes they may be very sluggish and show but little fight. Yet this is by no means always true. In the Klamath Lakes, where the trout grow very large and

where they are often very logy, one is occasionally hooked which tries to the utmost the skill of the angler to prevent his tackle from being smashed and at the same time save the fish."

Of the various forms derived from *Salmo clarkii* some mere varieties, some distinct species, the following are among the most marked:

Salmo henshawi, the trout of Lake Tahoe and its tributaries and outlet, Truckee River, found in fact also in the Humboldt

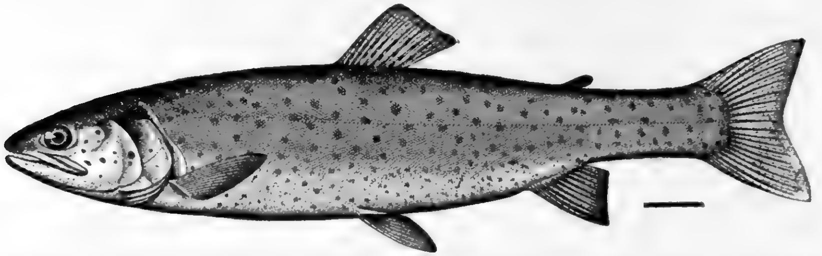


FIG. 66.—Tahoe Trout, *Salmo henshawi* Gill & Jordan. Lake Tahoe, California.

and the Carson and throughout the basin of the former glacial lake called Lake Lahontan. This is a distinct species from *Salmo clarkii* and must be regarded as the finest of all the cut-throat-trout. It is readily known by its spotted belly, the black spots being evenly scattered over the whole surface of the body, above and below. This is an excellent game-fish, and from Lake Tahoe and Pyramid Lake it is brought in large numbers to the markets of San Francisco. In the depths of Lake Tahoe, which is the finest mountain lake of the Sierra Nevada, occurs a very large variety which spawns in the lake, *Salmo henshawi tahoensis*. This reaches a weight of twenty-eight pounds.

In the Great Basin of Utah is found a fine trout, very close to the ordinary cutthroat of the Columbia, from which it is derived. This is known as *Salmo clarkii virginalis*. In Utah Lake it reaches a large size.

In Waha Lake in Washington, a lake without outlet, is found a small trout with peculiar markings called *Salmo clarkii bouvieri*.

In the head-waters of the Platte and Arkansas rivers is the small green-back trout, green or brown, with red throat-patch

and large black spots. This is *Salmo clarkii stomias*, and it is especially fine in St. Vrain's River and the streams of Estes Park.

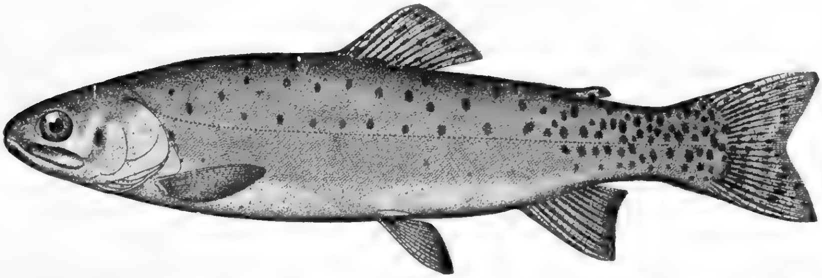


FIG. 67.—Green-back Trout, *Salmo stomias* Cope. Arkansas River, Leadville, Colo.

In Twin Lakes, a pair of glacial lakes tributary of the Arkansas near Leadville, is found *Salmo clarkii macdonaldi*, the yellow-finned trout, a large and very handsome species living in deep water, and with the fins golden yellow. This approaches the Colorado trout, *Salmo clarkii pleuriticus*, and it may be derived

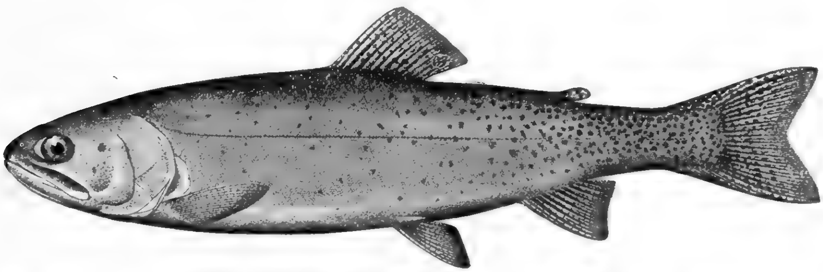


FIG. 68.—Yellow-fin Trout of Twin Lakes, *Salmo macdonaldi* Jordan & Evermann. Twin Lakes, Colo.

from the latter, although it occurs in the same waters as the very different green-back trout, or *Salmo clarkii stomias*.

Two fine trout derived from *Salmo clarkii* have been lately discovered by Dr. Daniel G. Elliot in Lake Southerland, a mountain lake near Lake Crescent, but not connected with it, the two separated from the sea by high waterfalls. These have been described by Dr. Seth E. Meek as *Salmo jordani*, the "spotted trout" of Lake Southerland, and *Salmo declivifrons*, the "salmon-trout." These seem to be distinct forms or subspecies produced through isolation.

The Rio Grande trout (*Salmo clarkii spilurus*) is a large and profusely spotted trout, found in the head-waters of the Rio

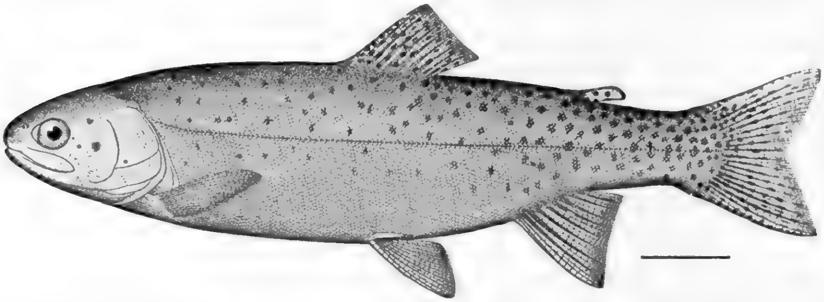


Fig. 69.—Rio Grande Trout, *Salmo clarkii spilurus* Cope. Del Norte, Colo.

Grande, the mountain streams of the Great Basin of Utah, and as far south as the northern part of Chihuahua. Its scales are still smaller than those of the ordinary cutthroat-trout, and the black spots are chiefly confined to the tail. Closely related to

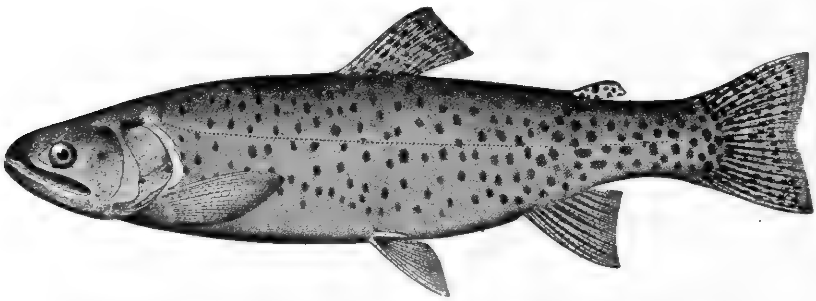


Fig. 70.—Colorado River Trout, *Salmo clarkii pleuriticus* Cope. Trapper's Lake, Colo.

it is the trout of the Colorado Basin, *Salmo clarkii pleuriticus*, a large and handsome trout with very small scales, much sought by anglers in western Colorado, and abounding in all suitable streams throughout the Colorado Basin.

Hucho, the Huchen. — The genus *Hucho* has been framed for the Huchen or Rothfisch (*Hucho hucho*) of the Danube, a very large trout, differing from the genus *Salmo* in having no teeth on the shaft of the vomer, and from the *Salvelini* at least in form and coloration. The huchen is a long and slender, somewhat pike-like fish, with depressed snout and strong teeth.

The color is silvery, sprinkled with small black dots. It reaches a size little inferior to that of the salmon, and it is said to be an excellent food-fish. In northern Japan is a similar species,

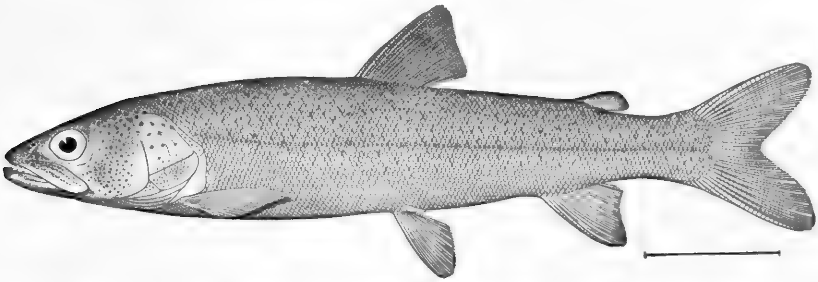


FIG. 71.—Ito, *Hucho blackistoni* (Hilgendorf). Hokkaido, Japan

Hucho blackistoni, locally known as Ito, a large and handsome trout with very slender body, reaching a length of 2½ feet. It is well worthy of introduction into American and European waters.

Salvelinus, the Charr.—The genus *Salvelinus* comprises the finest of the *Salmonidæ*, from the point of view of the angler or the artist. In England the species are known as charr or char, in contradistinction to the black-spotted species of *Salmo*, which are called trout. The former name has unfortunately been lost in America, where the name "trout" is given indiscriminately to both groups, and, still worse, to numerous other fishes (*Micropterus*, *Hexagrammos*, *Cynoscion*, *Agonostomus*) wholly unlike the *Salmonidæ* in all respects. It is sometimes said that "the American brook-trout is no trout, nothing but a charr," almost as though "charr" were a word of reproach. Nothing higher, however, can be said of a salmonoid than that it is a "charr." The technical character of the genus *Salvelinus* lies in the form of its vomer. This is deeper than in *Salmo;* and when the flesh is removed the bone is found to be somewhat boat-shaped above, and with the shaft depressed and out of the line of the head of the vomer. Only the head or chevron is armed with teeth, and the shaft is covered by skin.

In color all the charrs differ from the salmon and trout. The body in all is covered with round spots which are paler than the ground color, and crimson or gray. The lower fins are

usually edged with bright colors. The sexual differences are not great. The scales, in general, are smaller than in other *Salmonidæ*, and they are imbedded in the skin to such a degree as to escape the notice of casual observers and even of most anglers.

> "One trout scale in the scales I'd lay
> (If trout had scales), and 'twill outweigh
> The wrong side of the balances."—LOWELL.

The charrs inhabit, in general, only the clearest and coldest of mountain streams and lakes, or bays of similar temperature. They are not migratory, or only to a limited extent. In northern regions they descend to the sea, where they grow much more rapidly and assume a nearly uniform silvery-gray color. The different species are found in all suitable waters throughout the northern parts of both continents, except in the Rocky Mountains and Great Basin, where only the black-spotted trout occur. The number of species of charr is very uncertain, as, both in America and Europe, trivial variations and individual peculiarities have been raised to the rank of species. More types, however, seem to be represented in America than in Europe.

The only really well-authenticated species of charr in European waters is the red charr, sälbling, or ombre chevalier (*Salvelinus alpinus*). This species is found in cold, clear streams in Switzerland, Germany, and throughout Scandinavia and the British Islands. Compared with the American charr or brook-trout, it is a slenderer fish, with smaller mouth, longer fins, and smaller red spots, which are confined to the sides of the

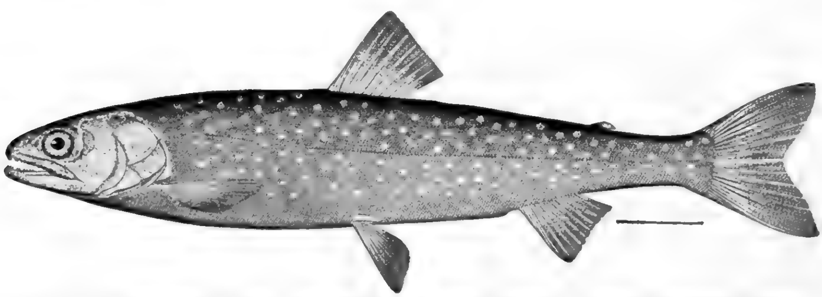


FIG. 72.—Rangeley Trout, *Salvelinus oquassa* (Girard). Lake Oquassa, Maine.

body. It is a "gregarious and deep-swimming fish, shy of taking the bait and feeding largely at night-time. It appears to require very pure and mostly deep water for its residence." It is less tenacious of life than the trout. It reaches a weight of from one to five pounds, probably rarely exceeding the latter in size. The various charr described from Siberia are far too little known to be enumerated here.

Of the American charr the one most resembling the European species is the Rangeley Lake trout (*Salvelinus oquassa*). The exquisite little fish is known in the United States only from the Rangeley chain of lakes in western Maine. This is very close to the Greenland charr, *Salvelinus stagnalis*, a beautiful species of the far north. The Rangeley trout is much slenderer than the common brook-trout, with much smaller head and smaller mouth. In life it is dark blue above, and the deep-red spots are confined to the sides of the body. The species rarely exceeds the length of a foot in the Rangeley Lakes, but in some other waters it reaches a much larger size. So far as is known it keeps itself in the depths of the lake until its spawning season approaches, in October, when it ascends the stream to spawn.

Still other species of this type are the Sunapee trout, *Salvelinus aureolus*, a beautiful charr almost identical with the

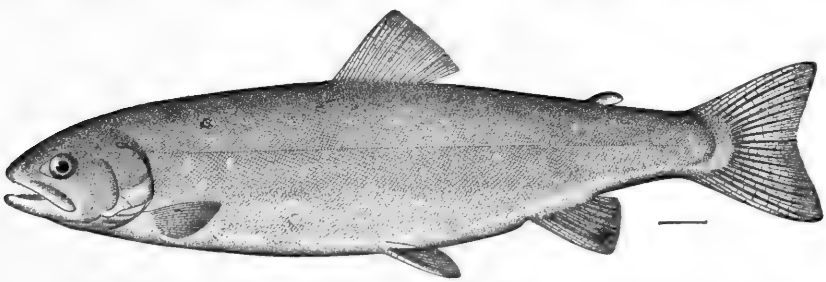


FIG. 73.—Sunapee Trout, *Salvelinus aureolus* Bean. Sunapee Lake, N. H.

European species, found in numerous ponds and lakes of eastern New Hampshire and neighboring parts of Maine. Mr. Garman regards this trout as the offspring of an importation of the ombre chevalier and not as a native species, and in this view he may be correct. *Salvelinus alipes* of the far north may be the same species. Another remarkable form is the Lac de Marbre trout of Canada, *Salvelinus marstoni* of Garman.

In Arctic regions another species, called *Salvelinus naresi*, is very close to *Salvelinus oquassa* and may be the same.

Another beautiful little charr, allied to *Salvelinus stagnalis*, is the Floeberg charr (*Salvelinus arcturus*). This species has been brought from Victoria Lake and Floeberg Beach, in the

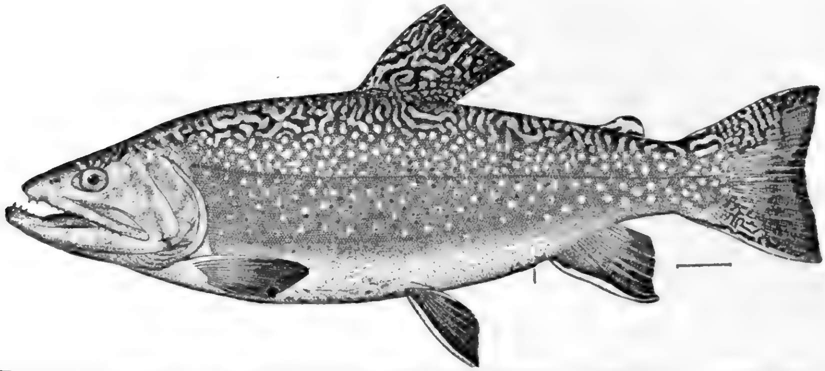


FIG. 74.—Speckled Trout (male), *Salvelinus fontinalis* (Mitchill). New York.

extreme northern part of Arctic America, the northernmost point whence any salmonoid has been obtained.

The American charr, or, as it is usually called, the brook-trout (*Salvelinus fontinalis*), although one of the most beautiful of fishes, is perhaps the least graceful of all the genuine charrs. It is technically distinguished by the somewhat heavy head and large mouth, the maxillary bone reaching more or less beyond the eye. There are no teeth on the hyoid bone, traces at least of such teeth being found in nearly all other species. Its color is somewhat different from that of the others, the red spots being large and the black more or less mottled and barred with darker olive. The dorsal and caudal fins are likewise barred or mottled, while in the other species they are generally uniform in color. The brook-trout is found only in streams east of the Mississippi and Saskatchewan. It occurs in all suitable streams of the Alleghany region and the Great Lake system, from the Chattahoochee River in northern Georgia northward at least to Labrador and Hudson Bay, the northern limits of its range being as yet not well ascertained. It varies greatly in size, according to its surroundings, those found in lakes being larger than those resident in small brooks. Those found

FIG. 75.—Brook Trout, *Salvelinus fontinalis* (Mitchill), natural size. (From life by Dr. R. W. Shufeldt.)

farthest south, in the head-waters of the Chattahoochee, Savannah, Catawba, and French Broad, rarely pass the dimensions of fingerlings. The largest specimens are recorded from the sea along the Canadian coast. These frequently reach a weight of ten pounds; and from their marine and migratory habits, they have been regarded as forming a distinct variety (*Salvelinus fontinalis immaculatus*), but this form is merely a sea-run brook-trout. The largest fresh-water specimens rarely exceed seven pounds in weight. Some unusually large brook-trout have been taken in the Rangeley Lakes, the largest known to me having a reputed weight of eleven pounds. The brook-trout is the favorite game-fish of American waters, preëminent in wariness, in beauty, and in delicacy of flesh. It inhabits all clear and cold waters within its range, the large lakes and the smallest ponds, the tiniest brooks and the largest rivers; and when it can do so without soiling its aristocratic gills on the way, it descends to the sea and grows large and fat on the animals of the ocean. Although a bold biter it is a wary fish, and it often requires much skill to capture it. It can be caught, too, with artificial or natural flies, minnows, crickets, worms, grasshoppers, grubs, the spawn of other fish, or even the eyes or cut pieces of other trout. It spawns in the fall, from September to late in November. It begins to reproduce at the age of two years, then having a length of about six inches. In spring-time the trout delight in rapids and swiftly running water; and in the hot months of midsummer they resort to deep, cool, and shaded pools. Later, at the approach of the spawning season, they gather around the mouths of cool, gravelly brooks, whither they resort to make their beds.*

The trout are rapidly disappearing from our streams through the agency of the manufacturer and the summer boarder. In the words of an excellent angler, the late Myron W. Reed of Denver: "This is the last generation of trout-fishers. The children will not be able to find any. Already there are well-trodden paths by every stream in Maine, in New York, and in Michigan. I know of but one river in North America by the side of which you will find no paper collar or other evidence of civilization. It is the Nameless River. Not that trout will

* Hallock.

cease to be. They will be hatched by machinery and raised in ponds, and fattened on chopped liver, and grow flabby and lose their spots. The trout of the restaurant will not cease to be. He is no more like the trout of the wild river than the fat and songless reedbird is like the bobolink. Gross feeding and easy pond-life enervate and deprave him. The trout that the children will know only by legend is the gold-sprinkled, living arrow of the white water; able to zigzag up the cataract; able to loiter in the rapids; whose dainty meat is the glancing butterfly."

The brook-trout adapts itself readily to cultivation in artificial ponds. It has been successfully transported to Europe, and it is already abundant in certain streams in England, in California, and elsewhere.

In Dublin Pond, New Hampshire, is a gray variety without red spots, called *Salvelinus agassizi*.

The "Dolly Varden" trout, or malma (*Salvelinus malma*), is very similar to the brook-trout, closely resembling it in size, form, color, and habits. It is found always to the westward of the Rocky Mountains, in the streams of northern California, Oregon,

Fig. 76.—Malma Trout, or "Dolly Varden," *Salvelinus malma* (Walbaum). Cook Inlet, Alaska.

Washington, and British Columbia, Alaska, and Kamtchatka, as far as the Kurile Islands. It abounds in the sea in the northward, and specimens of ten to twelve pounds weight are not uncommon in Puget Sound and especially in Alaska. The Dolly Varden trout is, in general, slenderer and less compressed than the Eastern brook-trout. The red spots are found on the back of the fish as well as on the sides, and the back and upper fins are without the blackish marblings and blotches seen in

Salvelinus fontinalis. In value as food, in beauty, and in gaminess *Salvelinus malma* is very similar to its Eastern cousin.

In Alaska the Dolly Varden, locally known as salmon-trout, is very destructive to the eggs of the salmon, and countless numbers are taken in the salmon-nets of Alaska and thrown away as useless by the canners. In every coastwise stream of Alaska

Fig. 77.—The Dolly Varden Trout, *Salvelinus malma* (Walbaum). Lake Pend d'Oreille, Idaho. (After Evermann.)

the water fairly "boils" with these trout. They are, however, not found in the Yukon. In northern Japan occurs *Salvelinus pluvius*, the iwana, a species very similar to the Dolly Varden, but not so large or so brightly colored. In the Kurile region and Kamtchatka is another large charr, *Salvelinus kundscha*, with the spots large and cream-color instead of crimson.

Cristivomer, the Great Lake Trout.—Allied to the true charrs, but now placed by us in a different genus, *Cristivomer*, is the

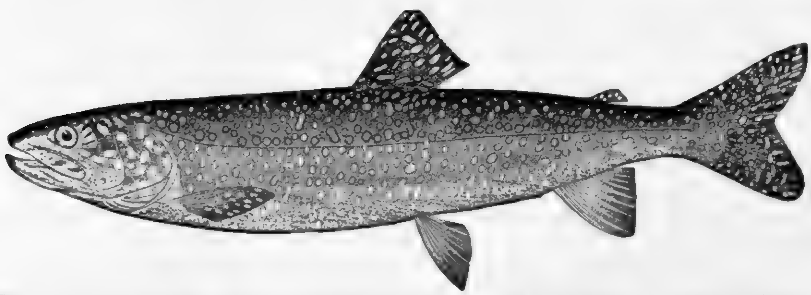


Fig. 78.—Great Lake Trout, *Cristivomer namaycush* (Walbaum). Lake Michigan.

Great Lake trout, otherwise known as Mackinaw trout, longe, or togue (*Cristivomer namaycush*). Technically this fish differs from the true charrs in having on its vomer a raised crest behind

the chevron and free from the shaft. This crest is armed with strong teeth. There are also large hooked teeth on the hyoid bone, and the teeth generally are proportionately stronger than in most of the other species. The Great Lake trout is grayish in color, light or dark according to its surroundings; and the body is covered with round paler spots, which are gray instead of red. The dorsal and caudal fins are marked with darker reticulations, somewhat as in the brook-trout. This noble species is found in all the larger lakes from New England and New York to Wisconsin, Montana, the Mackenzie River, and in all the lakes tributary to the Yukon in Alaska. We have taken examples from Lake Bennett, Lake Tagish, Summit Lake (White Pass), and have seen specimens from Lake La Hache in British Columbia. It reaches a much larger size than any *Salvelinus*, specimens of from fifteen to twenty pounds weight being not uncommon, while it occasionally attains a weight of fifty to eighty pounds. As a food-fish it ranks high, although it may be regarded as somewhat inferior to the brook-trout or the whitefish. Compared with other salmonoids, the Great Lake trout is a sluggish, heavy, and ravenous fish. It has been known to eat raw potato, liver, and corn-cobs,—refuse thrown from passing steamers. According to Herbert, "a coarse, heavy, stiff rod, and a powerful oiled hempen or flaxen line, on a winch, with a heavy sinker; a cod-hook, baited with any kind of flesh, fish, or fowl,—is the most successful, if not the most orthodox or scientific, mode of capturing him. His great size and immense strength alone give him value as a fish of game; but when hooked he pulls strongly and fights hard, though he is a boring, deep fighter, and seldom if ever leaps out of the water, like the true salmon or brook-trout."

In the depths of Lake Superior is a variety of the Great Lake trout known as the Siscowet (*Cristivomer namaycush siskawitz*), remarkable for its extraordinary fatness of flesh. The cause of this difference lies probably in some peculiarity of food as yet unascertained.

The Ayu, or Sweetfish. — The ayu, or sweetfish, of Japan, *Plecoglossus altivelis*, resembles a small trout in form, habits, and scaling. Its teeth are, however, totally different, being arranged on serrated plates on the sides of the jaws, and the tongue marked with similar folds. The ayu abounds in all

clear streams of Japan and Formosa. It runs up from the sea like a salmon. It reaches the length of about a foot. The

Fig. 79.—Ayu, or Japanese Samlet, *Plecoglossus altivelis* Schlegel. Tamagawa, Tokyo, Japan.

flesh is very fine and delicate, scarcely surpassed by that of any other fish whatsoever. It should be introduced into clear short streams throughout the temperate zones.

In the river at Gifu in Japan and in some other streams the ayu is fished for on a large scale by means of tamed cormorants. This is usually done from boats in the night by the light of torches.

Cormorant-fishing.—The following account of cormorant-fishing is taken, by the kind permission of Mr. Caspar W. Whitney, from an article contributed by the writer to *Outing*, April, 1902:

Tamagawa means Jewel River, and no water could be clearer. It rises somewhere up in the delectable mountains to the eastward of Musashi, among the mysterious pines and green-brown fir-trees, and it flows across the plains bordered by rice-fields and mulberry orchards to the misty bay of Tokyo. It is, therefore, a river of Japan, and along its shores are quaint old temples, each guarding its section of primitive forest, picturesque bridges, huddling villages, and torii, or gates through which the gods may pass.

The stream itself is none too large—a boy may wade it—but it runs on a wide bed, which it will need in flood-time, when the snow melts in the mountains. And this broad flood-bed is

filled with gravel, with straggling willows, showy day-lilies, orange amaryllis, and the little sky-blue spider-flower, which the Japanese call chocho, or butterfly-weed.

In the Tamagawa are many fishes: shining minnows in the white ripples, dark catfishes in the pools and eddies, and little sculpins and gobies lurking under the stones. Trout dart through its upper waters, and at times salmon run up from the sea.

But the one fish of all its fishes is the ayu. This is a sort of dwarf salmon, running in the spring and spawning in the rivers just as a salmon does. But it is smaller than any salmon, not larger than a smelt, and its flesh is white and tender, and so very delicate in its taste and odor that one who tastes it crisply fried or broiled feels that he has never tasted real fish before. In all its anatomy the ayu is a salmon, a dwarf of its kind, one which our ancestors in England would have called a "samlet." Its scientific name is *Plecoglossus altivelis*. *Plecoglossus* means plaited tongue, and *altivelis*, having a high sail; for the skin of the tongue is plaited or folded in a curious way, and the dorsal fin is higher than that of the salmon, and one poetically inclined might, if he likes, call it a sail. The teeth of the ayu are very peculiar, for they constitute a series of saw-edged folds or plaits along the sides of the jaws, quite different from those of any other fish whatsoever.

In size the ayu is not more than a foot to fifteen inches long. It is like a trout in build, and its scales are just as small. It is light yellowish or olive in color, growing silvery below. Behind its gills is a bar of bright shining yellow, and its adipose fin is edged with scarlet. The fins are yellow, and the dorsal fin shaded with black, while the anal fin is dashed with pale red.

So much for the river and the ayu. It is time for us to go afishing. It is easy enough to find the place, for it is not more than ten miles out of Tokyo, on a fine old farm just by the ancient Temple of Tachikawa, with its famous inscribed stone, given by the emperor of China.

At the farmhouse, commodious and hospitable, likewise clean and charming after the fashion of Japan, we send for the boy who brings our fishing-tackle.

They come waddling into the yard, the three birds with which we are to do our fishing. Black cormorants they are, each with a white spot behind its eye, and a hoarse voice, come of standing in the water, with which it says *y-eugh* whenever a stranger makes a friendly overture. The cormorants answer to the name of Ou, which in Japanese is something like the only word the cormorants can say. The boy puts them in a box together and we set off across the drifted gravel to the Tamagawa. Arrived at the stream, the boy takes the three cormorants out of the box and adjusts their fishing-harness. This consists of a tight ring about the bottom of the neck, of a loop under each wing, and a directing line.

Two other boys take a low net. They drag it down the stream, driving the little fishes—ayu, zakko, haë, and all the rest—before it. The boy with the cormorants goes in advance. The three birds are eager as pointer dogs, and apparently full of perfect enjoyment. To the right and left they plunge with lightning strokes, each dip bringing up a shining fish. When the bird's neck is full of fishes down to the level of the shoulders, the boy draws him in, grabs him by the leg, and shakes him unceremoniously over a basket until all the fishes have flopped out.

The cormorants watch the sorting of the fish with eager eyes and much repeating of *y-eugh*, the only word they know. The ayu are not for them, and some of the kajikas and hazés were prizes of science. But zakko (the dace) and haë (the minnow) were made for the cormorant. The boy picks out the chubs and minnows and throws them to one bird and then another. Each catches his share on the fly, swallows it at one gulp, for the ring is off his neck by this time, and then says *y-eugh*, which means that he likes the fun, and when we are ready will be glad to try again. And no doubt they have tried it many times since, for there are plenty of fishes in the Jewel River, zakko and haë as well as ayu.

Fossil Salmonidæ.—Fossil salmonidæ are rare and known chiefly from detached scales, the bones in this family being very brittle and easily destroyed. Nothing is added to our knowledge of the origin of these fishes from such fossils.

A large fossil trout or salmon, called *Rhabdofario lacustris*,

has been brought from the Pliocene at Catherine's Creek, Idaho. It is known from the skull only. *Thaumaturus luxatus*, from the Miocene of Bohemia, shows the print of the adipose fin. As already stated (p. 62), fragments of the hooked jaws of salmon, from pleistocene deposits in Idaho, are in the museum of the University of California.

CHAPTER VI

THE GRAYLING AND THE SMELT

THE Grayling, or Thymallidæ.—The small family of *Thymallidæ*, or grayling, is composed of finely organized fishes allied to the trout, but differing in having the frontal bones meeting on the middle line of the skull, thus excluding the frontals from contact with the supraoccipital. The anterior half of the very high dorsal is made up of unbranched simple rays. There is but one genus, *Thymallus*, comprising very noble game-fishes characteristic of sub-arctic streams.

The grayling, *Thymallus*, of Europe, is termed by Saint Ambrose "the flower of fishes." The teeth on the tongue,

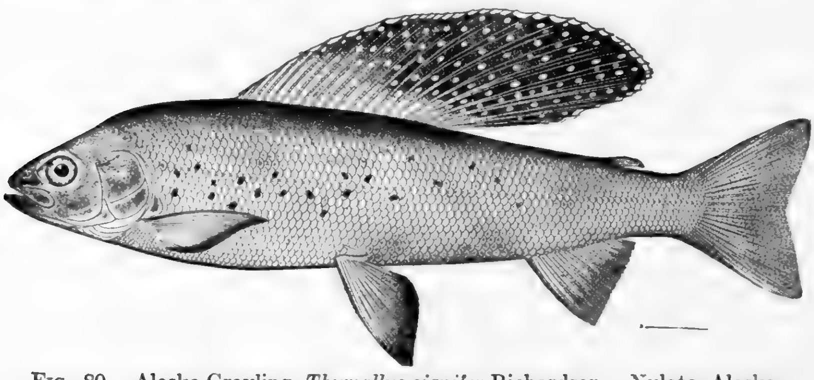


FIG. 80.—Alaska Grayling, *Thymallus signifer* Richardson. Nulato, Alaska.

found in all the trout and salmon, are obsolete in the grayling. The chief distinctive peculiarity of the genus *Thymallus* is the great development of the dorsal fin, which has more rays (20 to 24) than are found in any of the *Salmonidæ*, and the fin is also higher. All the species are gaily colored, the dorsal fin especially being marked with purplish or greenish bands

and bright rose-colored spots; while the body is mostly purplish gray, often with spots of black. Most of the species rarely exceed a foot in length, but northward they grow larger. Grayling weighing five pounds have been taken in England; and according to Dr. Day they are said in Lapland to reach a weight of eight or nine pounds. The grayling in all countries frequent clear, cold brooks, and rarely, if ever, enter the sea, or even the larger lakes. They congregate in small shoals in the streams, and prefer those which have a succession of pools and shallows, with a sandy or gravelly rather than rocky bottom. The grayling spawns on the shallows in April or May (in England). It is non-migratory in its habits, depositing its ova in the neighborhood of its usual haunts. The ova are far more delicate and easily killed than those of the trout or charr. The grayling and the trout often inhabit the same waters, but not altogether in harmony. It is said that the grayling devours the eggs of the trout. It is certain that the trout feed on the young grayling. As a food-fish, the grayling of course ranks high; and it is beloved by the sportsman. They are considered gamy fishes, although less strong than the brook-trout, and perhaps less wary. The five or six known species of grayling are very closely related, and are doubtless comparatively recent offshoots from a common stock, which has now spread itself widely through the northern regions.

The common grayling of Europe (*Thymallus thymallus*) is found throughout northern Europe, and as far south as the mountains of Hungary and northern Italy. The name *Thymallus* was given by the ancients, because the fish, when fresh, was said to have the odor of water-thyme. Grayling belonging to this or other species are found in the waters of Russia and Siberia.

The American grayling (*Thymallus signifer*) is widely distributed in British America and Alaska. In the Yukon it is very abundant, rising readily to the fly. In several streams in northern Michigan, Au Sable River, and Jordan River in the southern peninsula, and Otter Creek near Keweenaw in the northern peninsula, occurs a dwarfish variety or species with shorter and lower dorsal fins, known to anglers as the Michigan grayling (*Thymallus tricolor*). This form has a longer head, rather smaller scales, and the dorsal fin rather lower than in

the northern form (*signifer*); but the constancy of these characters in specimens from intermediate localities is yet to be proved. Another very similar form, called *Thymallus montanus*, occurs in the Gallatin, Madison, and other rivers of Western Montana tributary to the Missouri. It is locally still abundant and one of the finest of game-fishes. It is probable that the grayling once had a wider range to the southward than now, and that so far as the waters of the United States are concerned it is tending toward extinction. This tendency is, of course, being

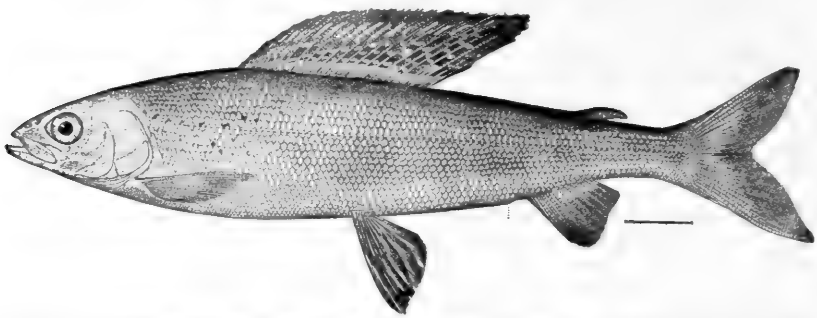


FIG. 81.—Michigan Grayling, *Thymallus tricolor* Cope. Au Sable River, Mich.

accelerated in Michigan by lumbermen and anglers. The colonies of grayling in Michigan and Montana are probably remains of a post-glacial fauna.

The Argentinidæ.—The family of *Argentinidæ*, or smelt, is very closely related to the *Salmonidæ*, representing a dwarf series of similar type. The chief essential difference lies in the form of the stomach, which is a blind sac, the two openings near together, and about the second or pyloric opening there are few if any pyloric cæca. In all the *Salmonidæ* the stomach has the form of a siphon, and about the pylorus there are very many pyloric cæca. The smelt have the adipose fin and the general structure of the salmon. All the species are small in size, and most of them are strictly marine, though some of them ascend the rivers to spawn, just as salmon do, but not going very far. A few kinds become land-locked in ponds. Most of the species are confined to the north temperate zone, and a few sink into the deep seas. All that are sufficiently abundant furnish excellent food, the flesh being extremely delicate and often charged with a fragrant oil easy of digestion.

The best-known genus, *Osmerus*, includes the smelt, or spirling (éperlan), of Europe, and its relatives, all excellent food-fishes, although quickly spoiling in warm weather. *Osmerus eperlanus* is the European species; *Osmerus mordax* of our eastern coast is very much like it, as is also the rainbow-smelt, *Osmerus dentex* of Japan and Alaska. A larger smelt, *Osmerus albatrossis*, occurs on the coast of Alaska, and a small and feeble one, *Osmerus thaleichthys*, mixed with other small or delicate fishes, is the whitebait of the San Francisco restaurants. The whitebait of the London epicure is made up of the young of herrings and sprats of different species. The still more delicate whitebait of the Hong Kong hotels is the icefish, *Salanx chinensis*.

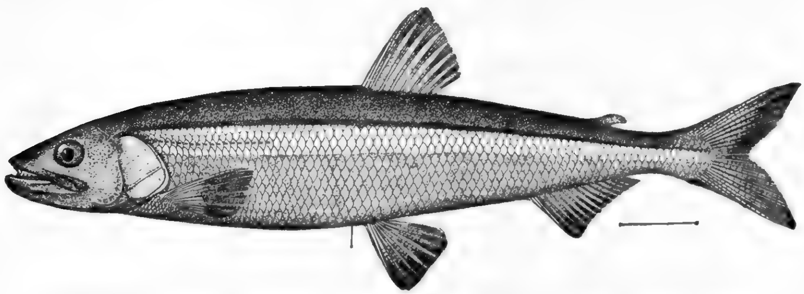


Fig. 82.—Smelt, *Osmerus mordax* (Mitchill). Wood's Hole, Mass.

Retropinna retropinna, so called from the backward insertion of its dorsal, is the excellent smelt of the rivers of New Zealand. All the other species belong to northern waters. *Mesopus*, the surf-smelt, has a smaller mouth than *Osmerus* and inhabits the North Pacific. The California species, *Mesopus pretiosus*, of Neah Bay has, according to James G. Swan, "the belly covered with a coating of yellow fat which imparts an oily appearance to the water where the fish has been cleansed or washed and makes them the very perfection of pan-fish." This species spawns in late summer along the surf-line. According to Mr. Swan the water seems to be filled with them. "They come in with the flood-tide, and when a wave breaks upon the beach they crowd up into the very foam, and as the surf recedes many will be seen flapping on the sand and shingle, but invariably returning with the undertow to deeper water." The Quilliute Indians of Washington believe that "the first

surf-smelts that appear must not be sold or given away to be taken to another place, nor must they be cut transversely, but split open with a mussel-shell."

The surf-smelt is marine, as is also a similar species, *Mesopus japonicus*, in Japan. *Mesopus olidus*, the pond-smelt of Alaska, Kamchatka, and Northern Japan, spawns in fresh-water ponds.

Still more excellent as a food-fish than even these exquisite species is the famous eulachon, or candle-fish (*Thaleichthys pacificus*). The Chinook name, usually written eulachon, is perhaps more accurately represented as ulchen. This little fish has the form of a smelt and reaches the length of nearly a foot. In the spring it ascends in enormous numbers all the

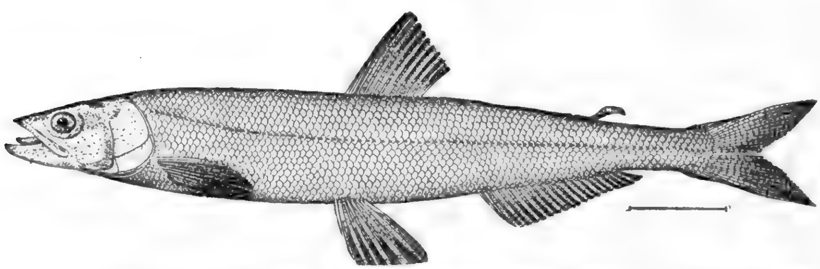


Fig. 83.—Eulachon, or Ulchen. *Thaleichthys pretiosus* Girard. Columbia River. Family *Argentinidæ*.

rivers north of the Columbia, as far as Skaguay, for a short distance for the purpose of spawning. These runs take place usually in advance of the salmon-runs. Various predatory fishes and sea-birds persecute the eulachon during its runs, and even the stomachs of the sturgeons are often found full of the little fishes, which they have taken in by their sucker-like mouths. At the time of the runs the eulachon are extremely fat, so much so that it is said that when dried and a wick drawn through the body they may be used as candles. On Nass River, in British Columbia, a stream in which their run is greatest, there is a factory for the manufacture of eulachon-oil from them. This delicate oil is proposed as a substitute for cod-liver oil in medicine. Whatever may be its merits in this regard, it has the disadvantage in respect to salability of being semi-solid or lard-like at ordinary temperatures, requiring melting to make it flow as oil. The eulachon is a favorite

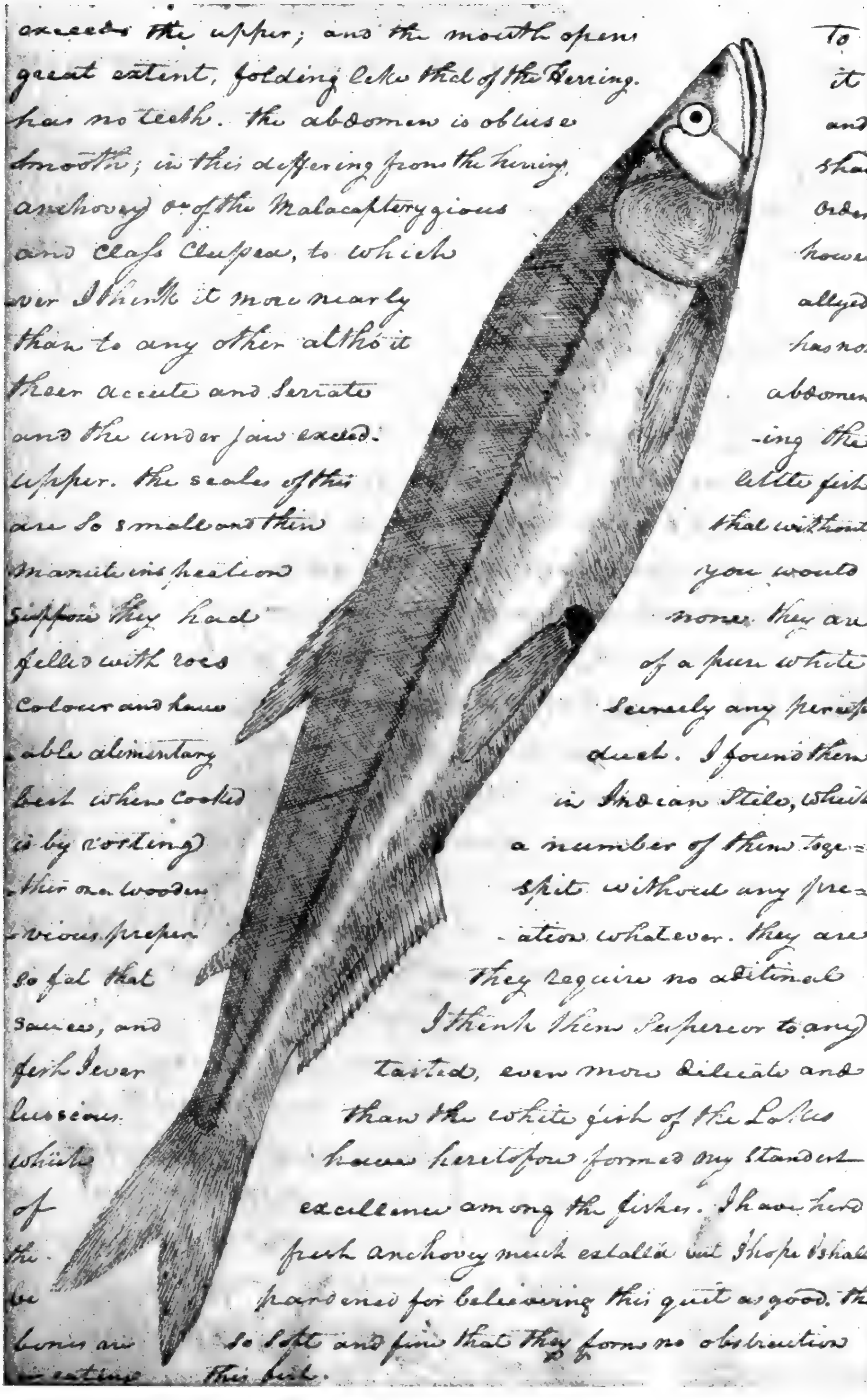

exceeds the upper; and the mouth opens to
great extent, folding like that of the Herring. it
has no teeth. the abdomen is obtuse and
smooth; in this differing from the herring, shad,
anchovey &c of the Malacapterygious Order
and Class Clupea, to which howe-
ver I think it more nearly allyed
than to any other altho it has not
their accute and serrate abdomen
and the under jaw exceed- -ing the
upper. the scales of this little fish
are so small and thin that without
manute inspection you would
suppose they had none. they are
filled with roes of a pure white
colour and have scercely any percept-
able alimentary duct. I found them
best when cooked in Indian stile, which
is by rosting a number of them toge-
ther on a wooden spit without any pre-
vious preper- ation whatever. they are
so fat that they require no aditional
sauces, and I think them superior to any
fish I ever tasted, even more delicate and
lussious than the white fish of the Lakes
which have heretofore formed my standard
of excellence among the fishes. I have herd
the fresh anchovey much estalled but I hope I shall
be pardoned for believing this quit as good. the
bones are so soft and fine that they form no obstruction
in eating this fish.

FIG. 84.—Page of William Clark's handwriting with sketch of the Eulachon (*Thaleichthys pacificus*), the first notice of the species. Columbia River, 1805. (Expedition of Lewis & Clark.) (Reproduced from the original in the possession of his granddaughter Mrs. Julia Clark Voorhis, through the courtesy of Messrs. Dodd, Mead & Company, publishers of the "Original Journals of the Lewis and Clark Expedition.")

pan-fish in British Columbia. The writer has had considerable experience with it, broiled and fried, in its native region, and has no hesitation in declaring it to be the best-flavored food-fish in American waters. It is fat, tender, juicy, and richly flavored, with comparatively few troublesome bones. It does not, however, bear transportation well. The Indians in Alaska bury the eulachon in the ground in great masses. After the fish are well decayed they are taken out and the oil pressed from them. The odor of the fish and the oil is then very offensive, less so, however, than that of some forms of cheese eaten by civilized people.

The capelin (*Mallotus villosus*) closely resembles the eulachon, differing mainly in its broader pectorals and in the peculiar scales of the males. In the male fish a band of scales above

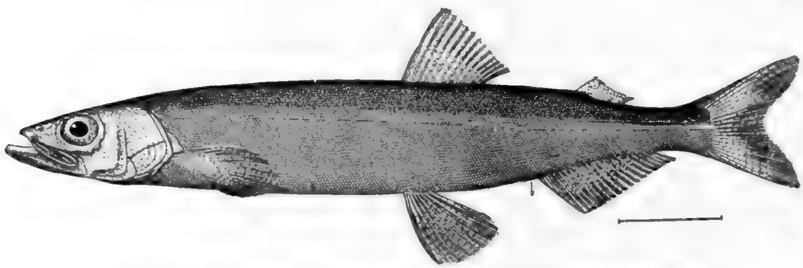


Fig. 85.—Capelin, *Mallotus villosus* L. Crosswater Bay.

the lateral line and along each side of the belly become elongate, closely imbricated, with the free points projecting, giving the body a villous appearance. It is very abundant on the coasts of Arctic America, both in the Atlantic and the Pacific, and is an important source of food for the natives of those regions.

This species spawns in the surf, and the writer has seen them in August cast on the shores of the Alaskan islands (as at Metlakahtla in 1897), living and dead, in numbers which seem incredible. The males are then distorted, and it seems likely that all of them perish after spawning. The young are abundant in all the northern fiords. Even more inordinate numbers are reported from the shores of Greenland.

The capelin seems to be inferior to the eulachon as a food-fish, but to the natives of arctic regions in both hemispheres it is a very important article of food. Fossil capelin are found

in abundance in recent shales in Greenland enveloped in nodules of clay. In the open waters about the Aleutian Islands a small smelt, *Therobromus callorhini*, occurs in very great abundance and forms the chief part of the summer food of the fur-seal. Strangely enough, no complete specimen of this fish has yet been seen by man, although thousands of fragments have been taken from seals' stomachs. From these fragments Mr. Frederick A. Lucas has reconstructed the fish, which must be an ally of the surf-smelt, probably spawning in the open ocean of the north.

The silvery species called *Argentina* live in deeper water and have no commercial importance. *Argentina silus*, with prickly scales, occurs in the North Sea. Several fossils have been doubtfully referred to *Osmerus*.

The Microstomidæ.—The small family of *Microstomidæ* consists of a few degraded smelt, slender in form, with feeble mouth and but three or four branchiostegals, rarely taken in the deep seas. *Nansenia grœnlandica* was found by Reinhardt off the coast of Greenland, and six or eight other species of *Microstoma* and *Bathylagus* have been brought in by the deep-sea explorations.

The Salangidæ, or Icefishes.—Still more feeble and insignificant are the species of *Salangidæ*, icefishes, or Chinese whitebait, which may be described as *Salmonidæ* reduced to the lowest terms. The body is long and slender, perfectly translucent, almost naked, and with the skeleton scarcely ossified. The fins are like those of the salmon, the head is depressed, the jaws long and broad, somewhat like the bill of a duck, and within there are a few disproportionately strong canine teeth, those of the lower jaw somewhat piercing the upper. The alimentary canal is straight for its whole length, without pyloric cæca. These little fishes, two to five inches long, live in the sea in enormous numbers and ascend the rivers of eastern Asia for the purpose of spawning. It is thought by some that they are annual fishes, all dying in the fall after reproduction, the species living through the winter only within its eggs. But this is only suspected, not proved, and the species will repay the careful study which some of the excellent naturalists of Japan are sure before long to give to it. The species of *Salanx* are known as whitebait, in Japan as *Shiro-uwo*, which means exactly the

same thing. They are also sometimes called icefish (*Hingio*), which, being used for no other fish, may be adopted as a group name for *Salanx*.

The species are *Salanx chinensis* from Canton, *Salanx hyalo cranius* from Korea and northern China, *Salanx microdon* from northern Japan, and *Salanx ariakensis* from the southern island of Kiusiu. The Japanese fishes are species still smaller and feebler than their relatives from the mainland.

The Haplochitonidæ. — The *Haplochitonidæ* are trout-like fishes of the south temperate zone, differing from the *Salmonidæ* mainly in the extension of the premaxillary until, as in the perch-like fishes, it forms the outer border of the upper jaw. The adipose fin is present as in all the salmon and smelt. *Haplochiton* of Tierra del Fuego and the Falkland Islands is naked, while in *Prototroctes* of Australia and New Zealand the body, as in all salmon, trout, and smelt, is covered with scales. *Prototroctes marœna* is the yarra herring of Australia. The closely related family of *Galaxiidæ*, also Australian, but lacking the adipose fin, is mentioned in a later chapter.

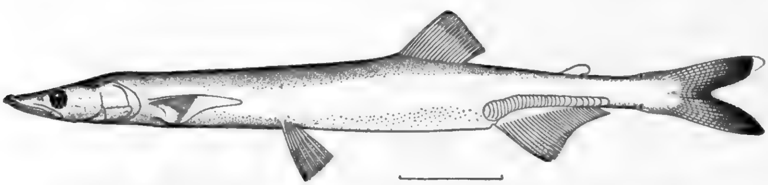


FIG. 86.—Icefish, *Salanx hyalocranius* Abbott. Family *Salangidæ*. Tientsin, China.

Stomiatidæ. — The *Stomiatidæ*, with elongate bodies, have the mouth enormous, with fang-like teeth, usually barbed. Of

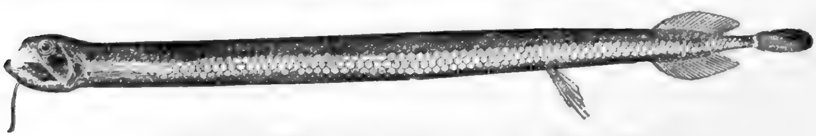


FIG. 87.—*Stomias ferox* Reinhardt. Banquereau.

the several species *Stomias ferox* is best known. According to Dr. Boulenger, these fishes are true *Isospondyli*.

Astronesthidæ is another small group of small fishes naked and black, with long canines, found in the deep sea.

The *Malacosteidæ* is a related group with extremely dis-

tensible mouth, the species capable of swallowing fishes much larger than themselves.

The viper-fishes (*Chauliodontidæ*) are very feeble and very voracious little fishes occasionally brought up from the depths. *Chauliodus sloanei* is notable for the length of the fangs.

Much smaller and feebler are the species of the closely related family of *Gonostomidæ*. *Gonostoma* and *Cyclothone* dwell in oceanic abysses. One species, *Cyclothone elongata*, occurs at the depth of from half a mile to nearly four miles

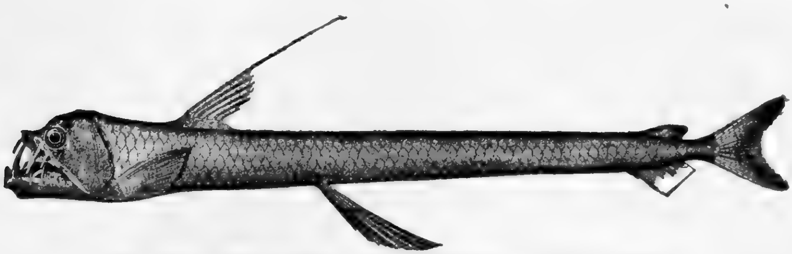


FIG. 88.—*Chauliodus sloanei* Schneider. Grand Banks.

almost everywhere throughout the oceans. It is probably the most widely distributed, as well as one of the feeblest and most fragile, of all bassalian or deep-sea fishes.

Suborder Iniomi, the Lantern-fishes.—The suborder *Iniomi* (*ἰνίον*, nape; *ὦμος*, shoulder) comprises soft-rayed fishes, in which the shoulder-girdle has more or less lost its completeness of structure as part of the degradation consequent on life in the abysses of the sea. These features distinguish these forms from the true *Isospondyli*, but only in a very few of the species have these characters been verified by actual examination of the skeleton. The mesocoracoid arch is wanting or atrophied in all of the species examined, and the orbitosphenoid is lacking, so far as known. The group thus agrees in most technical characters with the *Haplomi*, in which group they are placed by Dr. Boulenger. On the other hand the relationships to the *Isospondyli* are very close, and the *Iniomi* have many traits suggesting degenerate *Isospondyli*. The post-temporal has lost its usual hold on the skull and may touch the occiput on the sides of the cranium. Nearly all the species are soft in body, black or silvery over black in color, and all that live

in the deep sea are provided with luminous spots or glands giving light in the abysmal depths. These spots are wanting in the few shore species, as also in those which approach most nearly to the *Salmonidæ*, these being presumably the most primitive of the group. In these also the post-temporal touches the back of the cranium near the side. In the majority of the *Iniomi* the adipose fin of the *Salmonidæ* is retained. From the phosphorescent spots is derived the general name of lantern-fishes applied of late years to many of the species. Most of these are of recent discovery, results of the remarkable work in deep-sea dredging begun by the *Albatross* and the *Challenger*. All of the species are carnivorous, and some, in spite of their feeble muscles, are exceedingly voracious, the mouth being armed with veritable daggers and spears.

Aulopidæ.—Most primitive of the *Iniomi* is the family of *Aulopidæ*, having an adipose fin, a normal maxillary, and no luminous spots. The rough firm scales suggest those of the berycoid fishes. The few species of *Aulopus* and *Chlorophthalmus* are found in moderate depths. *Aulopus purpurissatus* is the "Sergeant Baker" of the Australian fishermen.

The Lizard-fishes.—The *Synodontidæ*, or lizard-fishes, have lizard-like heads with very large mouth. The head is scaly, a character rare among the soft-rayed fishes. The slender maxil-

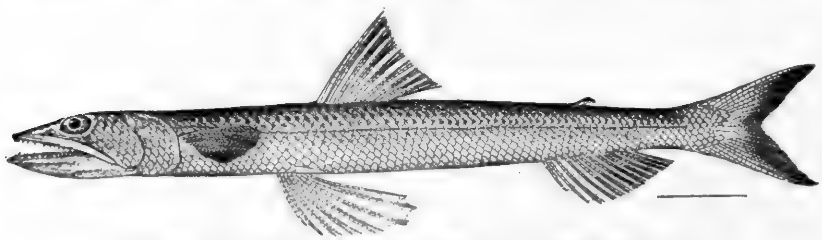


FIG. 89.—Lizard-fish, *Synodus fœtens* L. Charleston, S. C.

lary is grown fast to the premaxillary, and the color is not black. Most of the species are shore-fishes and some are brightly colored. *Synodus fœtens* is the common lizard-fish, or galliwasp, of our Atlantic coast. *Synodus varius* of the Pacific is brightly colored, olive-green and orange-red types of coloration existing at different depths. Most of the species lie close to the bottom and are mottled gray like coral sand. A few occur in

oceanic depths. The "Bombay duck" of the fishermen of India is a species of *Harpodon*, *H. nehereus*, with large mouth and arrow-shaped teeth. The dried fish is used as a relish.

The *Benthosauridæ* are deep-sea fishes of similar type, but with distinct maxillaries. The *Bathypteroidæ*, of the deep seas, resemble *Aulopus*, but have the upper and lower pectoral rays filiform, developed as organs of touch in the depths in which the small eyes become practically useless.

Ipnopidæ.—In the *Ipnopidæ* the head is depressed above and the two eyes are flattened and widened so as to occupy most of its upper surface. These structures were at first supposed to be luminous organs, but Professor Moseley has shown them to be eyes. "They show a flattened cornea extending along the median line of the snout, with a large retina composed of peculiar rods which form a complicated apparatus

FIG. 90.—*Ipnops murrayi* Günther.

destined undoubtedly to produce an image and to receive especial luminous rays." The single species, *Ipnops murrayi*, is black in color and found at the depth of 2½ miles in various seas.

The existence of well-developed eyes among fishes destined to live in the dark abysses of the ocean seems at first contradictory, but we must remember that these singular forms are descendants of immigrants from the shore and from the surface. "In some cases the eyes have not been specially modified, but in others there have been modifications of a luminous mucous membrane leading on the one hand to phosphorescent organs more or less specialized, or on the other to such remarkable structures as the eyes of *Ipnops*, intermediate between true eyes and phosphorescent plates. In fishes which cannot see, and which retain for their guidance only the general sensibility of the integuments and the lateral line, these parts soon acquire a very great delicacy. The same is the case with

tactile organs (as in *Bathypterois* and *Benthosaurus*), and experiments show that barbels may become organs of touch adapted to aquatic life, sensitive to the faintest movements or the slightest displacement, with power to give the blinded fishes full cognizance of the medium in which they live."

Rondeletiidæ.—The *Rondeletiidæ* are naked black fishes with small eyes, without adipose fin and without luminous spots,

FIG. 91.—*Cetomimus gillii* Goode & Bean. Gulf Stream.

taken at great depths in the Atlantic. The relationship of these fishes is wholly uncertain.

The *Cetomimidæ* are near allies of the *Rondeletiidæ*, having the mouth excessively large, with the peculiar form seen in the right whales, which these little fishes curiously resemble.

Myctophidæ.—The large family of *Myctophidæ*, or lantern-fishes, is made up of small fishes allied to the *Aulopidæ*, but

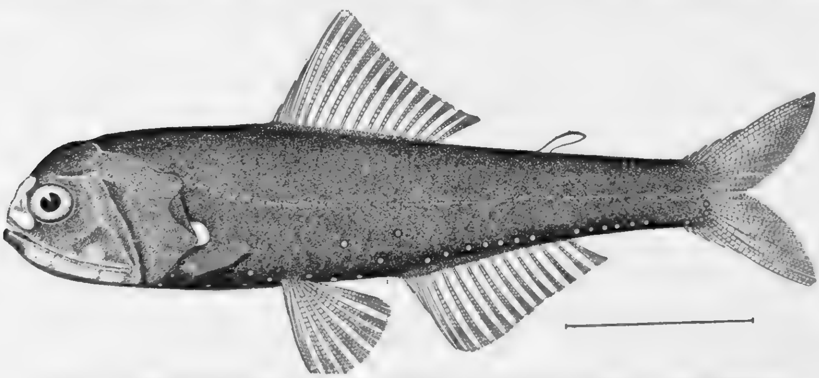


FIG. 92.—Headlight Fish, *Diaphus lucidus* Goode and Bean. Gulf Stream.

with the body covered with luminous dots, highly specialized and symmetrically arranged. Most of them belong to the deep sea, but others come to the surface in the night or during storms when the sunlight is absent. Through this habit they are often thrown by the waves on the decks of small vessels.

Largely from Danish merchant-vessels, Dr. Lütken has obtained the unrivaled collection of these sea-waifs preserved in the Museum of the University of Copenhagen. The species are all small in size and feeble in structure, the prey of the larger

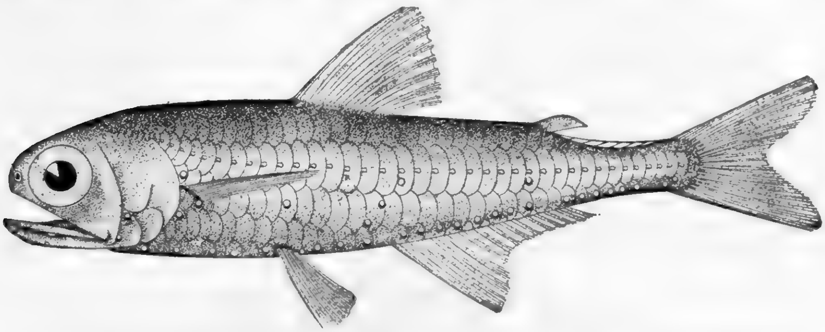


FIG. 93.—Lantern-fish, *Myctophum opalinum* Goode & Bean. Gulf Stream.

fishes of the depths, from which their lantern-like spots and large eyes help them to escape. The numerous species are now ranged in about fifteen genera, although earlier writers placed them all in a single genus *Myctophum* (*Scopelus*).

In the genus *Diaphus* (*Æthoprora*) there is a large luminous gland on the end of the short snout, like the headlight of an

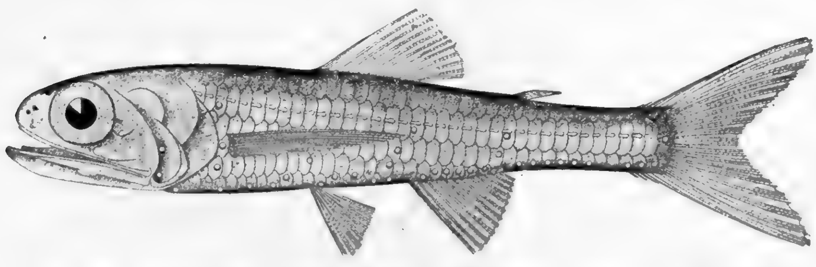


FIG. 94.—Lantern-fish, *Ceratoscopelus madeirensis* (Lowe). Gulf Stream.

engine. In *Dasyscopelus* the scales are spinescent, but in most of the genera, as in *Myctophum*, the scales are cycloid and caducous, falling at the touch. In *Diaphus* the luminous spots are crossed by a septum giving them the form of the Greek letter θ (theta). One of the commonest species is *Myctophum humboldti*.

Chirothricidæ.—The remarkable extinct family of *Chirothricidæ* may be related to the *Synodontidæ*, or *Myctophidæ*. In this group the teeth are feeble, the paired fins much

enlarged, and the ventrals are well forward. The dorsal fin, inserted well forward, has stout basal bones. *Chirothrix libanicus* of the Cretaceous of Mt. Lebanon is remarkable for its excessively large ventral fins. *Telepholis* is a related genus. *Exocœtoides* with rounded caudal fin is probably the type of a distinct family, *Exocœtoididæ*, the caudal fin being strongly forked in *Chirothrix*. The small extinct group of *Rhinellidæ* is usually placed near the *Myctophidæ*. They are distinguished by the very long gar-like jaws; whether they possessed adipose fins or luminous spots cannot be determined. *Rhinellus furcatus* and other species occur in the Cretaceous of Europe and Asia. Fossil forms more or less distinctly related to the *Myctophidæ* are numerous. *Osmeroides monasterii* (wrongly called *Sardinioides*), from the German Cretaceous, seems allied to *Myctophum*, although, of course, luminous spots leave no trace among fossils. *Acrognathus boops* is remarkable for the large size of the eyes.

FIG. 95.—*Rhinellus furcatus* Agassiz. Upper Cretaceous of Mt. Lebanon. (After Woodward.)

Maurolicidæ.— The *Maurolicidæ* are similar in form and habit, but scaleless, and with luminous spots more highly specialized. *Maurolicus pennanti*, the "Sleppy Argentine," is occasionally taken on either side of the Atlantic. Other genera are *Zalarges*, *Vinciguerria*, and *Valenciennellus*.

The Lancet-fishes.—The *Plagyodontidæ* (*Alepisauridæ*) contains the lancet-fishes, large, swift, scaleless fishes of the ocean depths with very high dorsal fin, and the mouth filled with knife-like teeth. These large fish are occasionally cast up by storms or are driven to the shores by the torments of a parasite, *Tetrarhynchus*, found imbedded in the flesh.

It is probable that they are sometimes killed by being forced above their level by fishes which they have swallowed. In such cases they are destroyed through the reduction of pressure.

Every part of the body is so fragile that perfect specimens are rare. The dorsal fin is readily torn, the bones are very

feebly ossified, and the ligaments connecting the vertebræ are very loose and extensible, so that the body can be considerably stretched. "This loose connection of the parts of the body is found in numerous deep-sea fishes, and is merely the consequence of their withdrawal from the pressure of the water to which they are exposed in the depths inhabited by them. When within the limits of their natural haunts, the osseous, muscular, and fibrous parts of the body will have that solidity which is required for the rapid and powerful movements of a predatory fish. That the fishes of this genus (*Plagyodus*) belong to the most ferocious of the class is proved by their dentition and the contents of their stomach." (Günther.) Dr. Günther else-

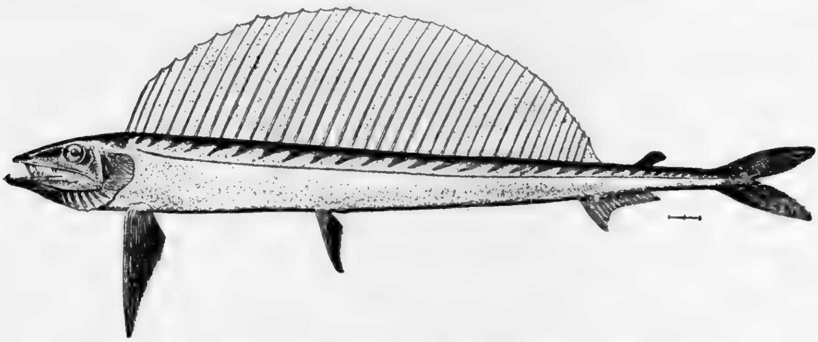


FIG. 96.—Lancet-fish, *Plagyodus ferox* (Lowe). New York.

where observes: "From the stomach of one example have been taken several octopods, crustaceans, ascidians, a young *Brama*, twelve young boarfishes (*Capros*), a horse-mackerel, and one young of its own species."

The lancet-fish, *Plagyodus ferox*, is occasionally taken on either side of the Atlantic and in Japan. The handsaw-fish, called *Plagyodus æsculapius*, has been taken at Unalaska, off San Luis Obispo, and in Humboldt Bay. It does not seem to differ at all from *Plagyodus ferox*. The original type from Unalaska had in its stomach twenty-one lumpfishes (*Eumicrotremus spinosus*). This is the species described from Steller's manuscripts by Pallas under the name of *Plagyodus*. Another species, *Plagyodus borcalis*, is occasionally taken in the North Pacific.

The *Evermannellidæ* is a small family of small deep-sea fishes

with large teeth, distensible muscles, and an extraordinary power of swallowing other fishes, scarcely surpassed by *Chiasmodon* or *Saccopharynx*. *Evermannellus* (*Odontostomus*, the latter name preoccupied) and *Omosudis* are the principal genera.

The *Paralepidæ* are reduced allies of *Plagyodus*, slender, silvery, with small fins and fang-like jaws. As in *Plagyodus*, the adipose fin is developed and there are small luminous dots. The species are few and mostly northern; one of them, *Sudis ringens*, is known only from a single specimen taken by the present writer from the stomach of a hake (*Merluccius productus*), the hake in turn swallowed whole by an albacore in the Santa Barbara Channel. The *Sudis* had been devoured by the hake, the hake by the albacore, and the albacore taken on the hook before the feeble *Sudis* had been digested.

Perhaps allied to the *Plagyodontidæ* is also the large family of *Enchodontidæ*, widely represented in the Cretaceous rocks of

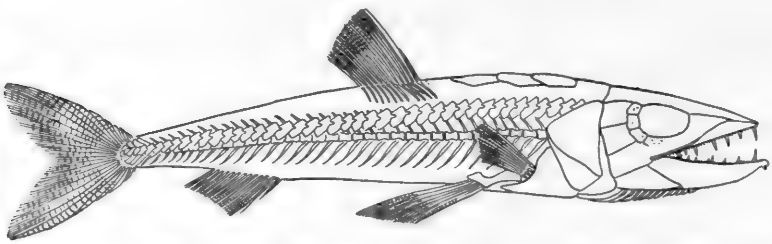


FIG. 97.—*Eurypholis sulcidens* Pictet, restored. Family *Enchodontidæ*. Upper Cretaceous of Mt. Lebanon. (After Woodward, as *E. boissieri*.)

Syria, Europe, and Kansas. The body in this group is elongate, the teeth very strong, and the dorsal fin short. *Enchodus lewesiensis* is found in Mount Lebanon, *Halec sternbergi* in the German Cretaceous, and many species of *Enchodus* in Kansas; *Cimolichthys dirus* in North Dakota.

Remotely allied to these groups is the extinct family of *Dercetidæ* from the Cretaceous of Germany and Syria. These are elongate fishes, the scales small or wanting, but with two or more series of bony scutes along the flanks. In *Dercetis scutatus* the scutes are large and the dorsal fin is very long. Other genera are *Leptotrachelus* and *Pelargorhynchus*. Dr. Boulenger places the *Dercetidæ* in the order *Heteromi*. This is an expression of the fact that their relations are still unknown. Probably

related to the *Dercetidæ* is the American family of *Stratodontidæ* with its two genera, *Stradodus* and *Empo* from the Cretaceous

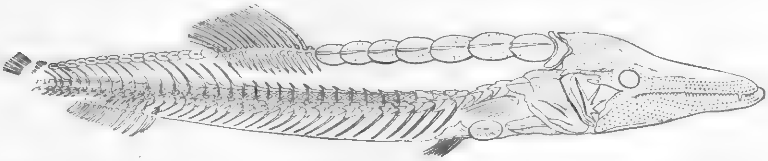


Fig. 98.—*Eurypholis freyeri* Heckel. Family *Enchodontidæ*. Cretaceous. (After Heckel; the restoration of the jaws incorrect.)

(Niobrara) deposits of Kansas. *Empo nepaholica* is one of the best-known species.

The Sternoptychidæ. — The *Sternoptychidæ* differ materially from all these forms in the short, compressed, deep body and distorted form. The teeth are small, the body bright silvery, with luminous spots. The species live in the deep seas, rising in dark or stormy weather. *Sternoptyx diaphana* is found in almost all seas, and species of *Argyropelecus* are almost

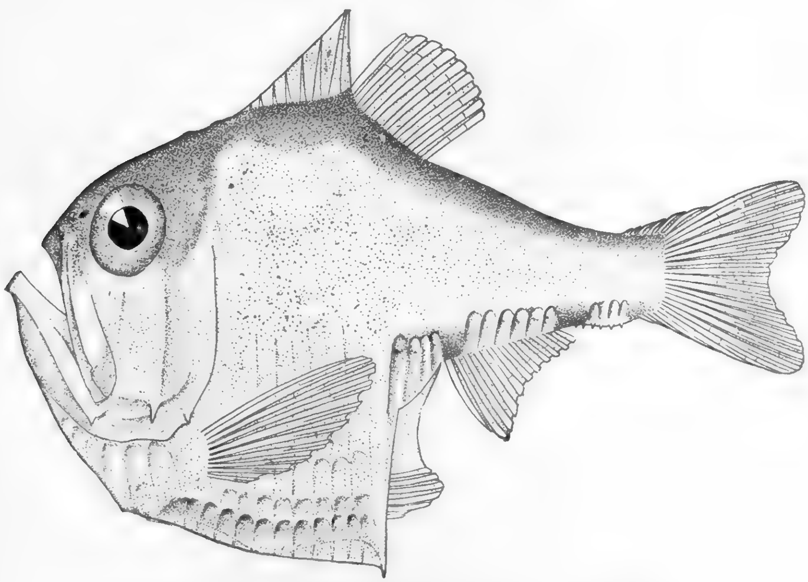


Fig. 99.—*Argyropelecus olfersi* Cuvier. Gulf Stream.

as widely distributed. After the earthquakes in 1896, which engulfed the fishing villages of Rikuzen, in northern Japan,

numerous specimens of this species were found dead, floating on the water, by the steamer *Albatross*.

The *Idiacanthidæ* are small deep-sea fishes, eel-shaped and without pectorals, related to the *Iniomi*.

Order Lyopomi.—Other deep-sea fishes constitute the order or suborder *Lyopomi* (λυός, loose; πῶμα, opercle). These are elongate fishes having no mesocoracoid, and the preopercle rudimentary and connected only with the lower jaw, the large

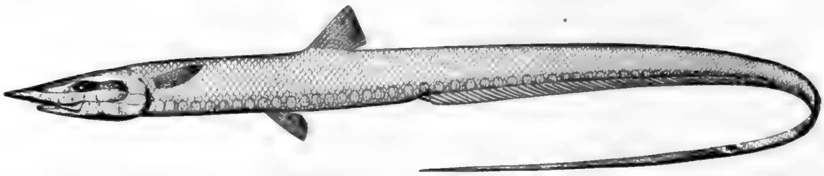


Fig. 100.—*Aldrovandia gracilis* (Goode & Bean). Guadaloupe Island, West Indies. Family *Halosauridæ*.

subopercle usurping its place. The group, which is perhaps to be regarded as a degenerate type of *Isospondyli*, contains the single family of *Halosauridæ*, with several species, black in color, soft in substance, with small teeth and long tapering tail, found in all seas. The principal genera are *Halosaurus* and *Aldrovandia* (*Halosauropsis*). *Aldrovandia macrochira* is the commonest species on our Atlantic coast.

Several fossil *Halosauridæ* are described from the Cretaceous of Europe and Syria, referred to the genera *Echidnocephalus* and *Enchelurus*. Boulenger refers the *Lyopomi* to the suborder *Heteromi*.

CHAPTER VII.

THE APODES, OR EEL-LIKE FISHES

THE Eels.—We may here break the sequence from the *Isospondyli* to the other soft-rayed fishes, to interpolate a large group of uncertain origin, the series or subclass of eels.

The mass of apodal or eel-like fishes has been usually regarded as constituting a single order, the Apodes (ἄ, without; ποῦς, foot). The group as a whole is characterized by the almost universal separation of the shoulder-girdle from the skull, by the absence of the mesocoracoid arch on the shoulder-girdle, by the presence of more than five pectoral actinosts, as in the Ganoid fishes, by the presence of great numbers of undifferentiated vertebræ, giving the body a snake-like form, by the absence in all living forms of the ventral fins, and, in all living forms, by the absence of a separate caudal fin. These structures indicate a low organization. Some of them are certainly results of degeneration, and others are perhaps indications of primitive simplicity. Within the limits of the group are seen other features of degeneration, notably shown in the progressive loss of the bones of the upper jaw and the membrane-bones of the head and the degradation of the various fins. The symplectic bone is wanting, the notochord is more or less persistent, the vertebral centra always complete constricted cylinders, none coalesced. But, notwithstanding great differences in these regards, the forms have been usually left in a single order, the more degraded forms being regarded as descended from the types which approach nearest to the ordinary fishes. From this view Professor Cope dissents. He recognizes several orders of eels, claiming that we should not unite all these various fishes into a single order on account of the eel-like form. If we do so, we should place in another order those with the fish-like form.

It is probable, though not absolutely certain, that the *Apodes* are related to each other. The loss among them, first, of the connection of the post-temporal with the skull; second, of the separate caudal fin and its hypural support; third, of the distinct maxillary and premaxillary; and fourth, of the pectoral fins, must be regarded as successive phases of a general line of degradation. The large number of actinosts, the persistence of the notochord, the absence of spines, and the large numbers of vertebræ seem to be traits of primitive simplicity. Special lines of degeneration are further shown by deep-sea forms. What the origin of the *Apodes* may have been is not known with any certainty. They are soft-rayed fishes, with the air-bladder connected by a tube with the œsophagus, and with the anterior vertebræ not modified. In so far they agree with the *Isospondyli*. In some other respects they resemble the lower *Ostariophysi*, especially the electric eel and the eel-like catfishes. But these resemblances, mainly superficial, may be wholly deceptive; we have no links which certainly connect the most fish-like Apodes with any of the other orders. Probably Woodward's suggestion that they may form a series parallel with the *Isospondyli* and independently descended from Tertiary Ganoids deserves serious consideration. Perhaps the most satisfactory arrangement of these fishes will be to regard them as constituting four distinct orders for which we may use the names *Symbranchia* (including *Ichthyocephali* and *Holostomi*), *Apodes* (including *Enchelycephali* and *Colocephali*), *Carencheli*, and *Lyomeri*.

Order Symbranchia.—The *Symbranchia* are distinguished by the development of the ordinary fish mouth, the maxillary and premaxillary being well developed. The gill-openings are very small, and usually confluent below. These fresh-water forms of the tropics, however eel-like in form, may have no real affinity with the true eels. In any event, they should not be placed in the same order with the latter.

The eels of the suborder *Ichthyocephali* (ἰχθύς, fish; κεφαλή, head) have the head distinctly fish-like. The maxillary, premaxillary, and palatines are well developed, and the shoulder-girdle is joined by a post-temporal to the skull. The body is distinctly eel-like, the tail being very short and the fins incon-

spicuous. The number of vertebræ is unusually large. The order contains the single family *Monopteridæ*, the rice-field eels, one species, *Monopterus albus*, being excessively common in pools and ditches from China and southern Japan to India.

The eels of the suborder *Holostomi* (ὀλός, complete; στόμα, mouth) differ from these mainly in the separation of the shoulder-girdle from the skull, a step in the direction of the true eels. The *Symbranchidæ* are very close to the *Monopteridæ* in external appearance, small, dusky, eel-like inhabitants of sluggish ponds and rivers of tropical America and the East Indies. The gill-openings are confluent under the throat. *Symbranchus marmoratus* ranges northward as far as Vera Cruz, having much the habit of the rice-field eel of Japan and China The *Amphipnoidæ*, with peculiar respiratory structures, abound in India. *Amphipnous cuchia*, according to Günther, has but three gill-arches, with rudimentary lamina and very narrow slits. To supplement this insufficient branchial apparatus, a lung-like sac is developed on each side of the body behind the head, opening between the hyoid and the first branchial arch. The interior of the sac is abundantly provided with blood-vessels, the arterial coming from the branchial arch, whilst those issuing from it unite to form the aorta. *Amphipnous* has rudimentary scales. The other *Holostomi* and *Ichthyocephali* are naked and all lack the pectoral fin.

The *Chilobranchidæ* are small sea-fishes from Australia, with the tail longer than the rest of the body, instead of much shorter as in the others.

No forms allied to *Symbranchus* or *Monopterus* are recorded as fossils.

Order Apodes, or True Eels. — In this group the shoulder-girdle is free from the skull, and the bones of the jaws are reduced in number, through coalescence of the parts.

Three well-marked suborders may be recognized, groups perhaps worthy of still higher rank: *Archencheli*, *Enchelycephali*, and *Colocephali*.

Suborder Archencheli.—The *Archencheli*, now entirely extinct, are apparently the parents of the eels, having, however, certain traits characteristic of the *Isospondyli*. They retain the separate caudal fin, with the ordinary hypural plate, and Professor

Hay has recently found, in an example from the Cretaceous of Mount Lebanon, remains of distinct ventral fins. These traits seem to indicate an almost perfect transition from the *Isospondyli* to the *Archencheli*.

One family may be recognized at present, *Urenchelyidæ*.

The earliest known eel, *Urenchelys avus*, occurs in the upper Cretaceous at Mount Lebanon. It represents the family *Urenchelyidæ*, apparently allied to the *Anguillidæ*, but having a separate caudal fin. Its teeth are small, conical, blunt, in many series. There are more than 100 vertebræ, the last expanded in a hypural. Pectorals present. Scales rudimentary; dorsal arising at the occiput. Branchiostegals slender, not curved around the opercle. *Urenchelys anglicus* is another species, found in the chalk of England.

Suborder Enchelycephali. — The suborder *Enchelycephali* (ἔγχελυς, eel; κεφαλή, head) contains the typical eels, in which the shoulder-girdle is free from the skull, the palatopterygoid arch relatively complete, the premaxillaries wanting or rudimentary, the ethmoid and vomer coalesced, forming the front of the upper jaw, the maxillaries lateral, and the cranium with a single condyle. In most of the species pectoral fins are present, and the cranium lacks the combined degradation and specialization shown by the morays (*Colocephali*).

Family Anguillidæ.—The most primitive existing family is that of the typical eels, *Anguillidæ*, which have rudimentary scales oblong in form, and set separately in groups at right angles with one another. These fishes are found in the fresh and brackish waters of all parts of the world, excepting the Pacific coast of North America and the islands of the Pacific. In the upper Great Lakes and the upper Mississippi they are also absent unless introduced. The species usually spawn in the sea and ascend the rivers to feed. But some individuals certainly spawn in fresh water, and none go far into the sea, or where the water is entirely salt. The young eels sometimes ascend the brooks near the sea in incredible numbers, constituting what is known in England as "eel-fairs." They will pass through wet grass to surmount ordinary obstacles. Niagara Falls they cannot pass, and according to Professor Baird "in the spring and summer the visitor who enters under the sheet of water at the foot of the

falls will be astonished at the enormous numbers of young eels crawling over the slippery rocks and squirming in the seething whirlpools. An estimate of hundreds of wagon-loads, as seen in the course of the perilous journey referred to, would hardly be considered excessive by those who have visited the spot at a suitable season of the year." "At other times large eels may be seen on their way down-stream, although naturally they are not as conspicuous then as are the hosts of the young on their way up-stream. Nevertheless it is now a well-assured fact that the eels are catadromous, that is, that the

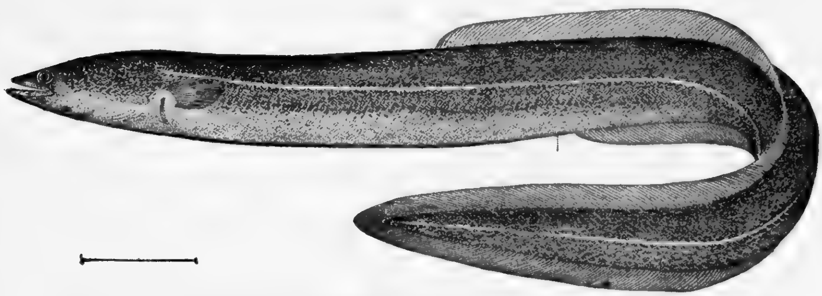


FIG. 101.—Common Eel, *Anguilla chrisypa* Rafinesque. Holyoke, Mass.

old descend the watercourses to the salt water to spawn, and the young, at least of the female sex, ascend them to enjoy life in the fresh water."

Reproduction of the Eel.—Dr. Gill ("Riverside Natural History," p. 103) gives the following account of the reproduction of *Anguilla:*

"The generation of the eel was long involved in great mystery, and the knowledge thereof is one of the recent acquisitions of scientific investigation. So late, indeed, as 1880 it was declared that 'their mode of propagation is still unknown.' In want of positive knowledge the rein has been given to loose hypothesis and conjecture. It has been variously asserted that eels were generated from slime, from dew, and from the skins of old eels or of snakes. The statement that they come from horse-hairs is familiar to many country boys, and the origin of this belief is due simply to the fact that there are certain aquatic worms, known under the generic name *Gordius*, which are elongated and apparently smooth like the eel, and which

may be found in the same waters. It was one of the ideas of the Greek to attribute their paternity, as of many other doubtful offspring, to the convenient Jupiter. The statement that they are viviparous has arisen from two causes: one the existence of intestinal worms, and the other from the confusion of the eel with an elongated and consequently eel-like but otherwise very different form, the *Zoarces viviparus*. The *Zoarces* is indeed, in Germany as well as in the Scandinavian countries, generally known as the Aal-mutter, or eel-mother, and thus in its name perpetuates the fancy. Even where eels are to be found in extreme abundance, and where they are the objects of a special culture, like erroneous opinions prevail. Thus, according to Jacoby, about the lagoon of Comacchio there is an 'ineradicable belief among the fishermen that the eel is born of other fishes; they point to special differences in color and especially in the common mullet, *Mugil cephalus*, as the causes of variation in color and form among eels. It is a very ancient belief, widely prevalent to the present day, that eels pair with water-snakes. In Sardinia the fishermen cling to the belief that a certain beetle, the so-called water-beetle, *Dytiscus ræselii*, is the progenitor of eels, and they therefore call this "mother of eels."' The assignment of such maternity to the water-beetle is doubtless due to the detection of the hair-worm, or Gordius, in the insect by sharp-sighted but unscientific observers, and, inasmuch as the beetle inhabits the same waters as the eel, a very illogical deduction has led to connect the two together.

"All such beliefs as have been thus recounted are due to the inconspicuous nature of the generative organs in eels found in fresh waters and at most seasons—a characteristic which is in strong contrast to the development of corresponding parts in fishes generally. Nevertheless the ovaries of the eel were discovered, as long ago as 1707, by Dr. Sancassini of Comacchio, and described by the celebrated Valisneri (after whom the plant *Valisneria* was named) in 1710, again by Mondini in 1777, and almost contemporaneously by O. J. Müller of Denmark. Later the illustrious Rathke (in 1824, 1838, and 1850) and also Hornbaum-Hornschuch published the results of special investigations, and figured the eggs. But it was only in 1873 (after several futile endeavors by others) that the male organ

of the eel was recognized, also by an Italian naturalist, Dr. Syrski, in small individuals of the species, and a previous idea that the eel was hermaphroditic thereby dispelled. The sexual differences are correlated with external ones, and generally the males and females, when adult, can be told apart. Jacoby testifies that he examined large numbers with a view to solve this question. The most important differences relate to (1) size; (2) form of the snout; (3) color; (4) dorsal fin; and (5) size of the eyes. (1) The males rarely attain a length of more than seventeen to nineteen inches, while adult females are generally much larger; (2) the snout in the male is attenuated and rather pointed, while in the female it is comparatively broad and blunt; (3) the male is of a deep darkish green, or often a deep black with a shining luster and a whitish belly, while the female has a clearer color, usually of a greenish hue on the back and yellowish on the belly; (4) the dorsal fin is lower and less developed in the male than in the female; and (5) the eye of the male is large and that of the female, as a rule, comparatively small. These characters, however, do not always hold good. Jacoby remarked that 'special reference having been paid to the height and narrowness of the dorsal fin, much success has been met with in picking out, in the fish-market of Trieste, the eels which possessed the organ of Syrski (that is, the male organ); absolute certainty, however, in recognizing them cannot be guaranteed. If one is searching among living eels with no characters in mind,—with the exception of the first, that of length,—he will find in every ten eels, on an average, eight females and two with the supposed male organ; but if the selection is made with a careful reference to all these marks of difference, the proportion changes, and out of every ten examples about eight will be found with the supposed male organ.'

"According to Herr Benecke, 'it may be assumed with the greatest safety that the eel lays its eggs like most other fish, and that, like the lamprey, it spawns only once and then dies. All the eggs of a female show the same degree of maturity, while in the fish which spawn every year, besides the large eggs which are ready to be deposited at the next spawning period, there exist very many of much smaller size, which are

destined to mature hereafter and be deposited in other years. It is very hard to understand how young eels could find room in the body of their mother if they were retained until they had gained any considerable size. The eel embryo can live and grow for a long time supported by the little yolk, but, when this is done, it can only obtain food outside of the body of its mother. The following circumstances lead us to believe that the spawning of the eel takes place only in the sea: (1) that the male eel is found only in the sea or brackish water, while female eels yearly undertake a pilgrimage from the inland waters to the sea, a circumstance which has been known since the time of Aristotle, and upon the knowledge of which the principal capture of eels by the use of fixed apparatus is dependent; (2) that the young eels, with the greatest regularity, ascend from the sea into the rivers and lakes.'"

All statements in opposition to this theory are untenable, since the young eels never find their way into landlocked ponds in the course of their wanderings, while eels planted in such isolated bodies of water thrive and grow rapidly, but never increase in numbers. Another still more convincing argument is the fact that in lakes which formerly contained many eels, but which, by the erection of impassable weirs, have been cut off from the sea, the supply of eels has diminished, and after a time only scattering individuals, old and of great size, are taken in them. An instance of this sort occurred in Lake Muskengorf in West Prussia. If an instance of the reproduction of the eel in fresh water could be found, such occurrences as these would be quite inexplicable.

In the upper stretches of long rivers the migration of the eels begins in April or in May; in their lower stretches and shorter streams, later in the season. In all running waters the eel-fishery depends upon the downward migrations; the eels press up the streams with occasional halts, remaining here and there for short periods, but always make their way above. They appear to make the most progress during dark nights, when the water is troubled and stormy, for at this time they are captured in the greatest numbers. It is probable that after the eels have once returned to the sea and there deposited their spawn, they never can return into fresh water, but remain

there to die. A great migration of grown eels in spring or summer has never been reported, and it appears certain that all the female eels which have once found their way to the sea are lost to the fisherman.

Food of the Eel.—Eels, in the words of Mr. W. H. Ballou, are "among the most voracious of carnivorous fishes. They eat most inland fishes, except the garfish and the chub. Investigation of six hundred stomachs by Oswego fishermen showed that the latter bony fish never had a place in their bill of fare. They are particularly fond of game-fishes, and show the delicate taste of a connoisseur in their selection from choice trout, bass, pickerel, and shad. They fear not to attack any object when disposed, and their bite in human flesh shows even a vicious attitude towards man. On their hunting excursions they overturn huge and small stones alike, working for hours if necessary, beneath which they find species of shrimp and crayfish, of which they are exceedingly fond. Of shrimps they devour vast numbers. Their noses are poked into every imaginable hole in their search for food, to the terror of innumerable small fishes."

In the opinion of Mr. Ballou, too, "eels are to the water what the fishhawk is to the air. They are, perhaps, the most powerful and rapid of natatorians. Again, they hide in the mud beneath some log or overhanging rock, and dart out with tremendous fury at the unsuspecting prey. They attack the spawn of other fishes open-mouthed, and are even said to suck the eggs from an impaled female. They fearlessly and rapidly dive head-foremost in the mud, disappearing from view in the twinkling of a star. They are owl-like in their habits, committing many of their depredations at night.

"No fish is yet reported to utilize a full-grown eel as food. Pickerel, garfish, and bass, which are particularly numerous in these lakes, are supposed to literally devour the young fry. Mr. Sawyer describes the operation of the pickerel darting through a long column of young eels open-mouthed and devouring vast numbers of them."

Larva of the Eel.—The translucent band-shaped larva of the common eel has been very recently identified and described by Dr. Eigenmann. It is probable that all true eels, *Enchely-*

cephali, pass through a band-shaped or leptocephalous stage, as is the case with *Albula* and other *Isospondyli*. In the continued growth the body becomes firmer, and at the same time

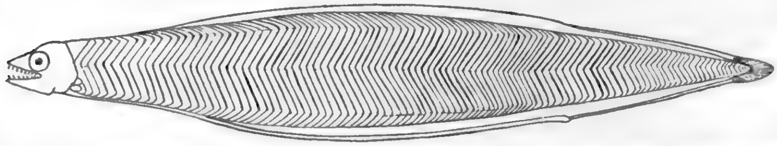


FIG. 102.—Larva of Common Eel, *Anguilla chrisypa* (Rafinesque), called *Leptocephalus grassii*. (After Eigenmann.)

much shorter and thicker, gradually assuming the normal form of the species in question.

In a recent paper Dr. Carl H. Eigenmann has very fully reviewed the life-history of the eel. The common species live in fresh waters, migrating to the sea in the winter. They deposit in deep water minute eggs that float at the surface. The next year they develop into the band-shaped larva. The young eels enter the streams two years after their parents drop down to the sea. It is doubtful whether eels breed in fresh water. The male eel is much smaller than the female.

The eel is an excellent food-fish, the flesh being tender and oily, of agreeable flavor, better than that of any of its relatives. Eels often reach a large size, old individuals of five or six feet in length being sometimes taken.

Species of Eels.—The different species are very closely related. Not more than four or five of them are sharply defined, and these mostly in the South Seas and in the East Indies. The three abundant species of the north temperate zone, *Anguilla anguilla* of Europe, *Anguilla chrisypa* of the eastern United States, and *Anguilla japonica* of Japan, are scarcely distinguishable. In color, size, form, and value as food they are all alike.

Fossil species referred to the *Anguillidæ* are known from the early Tertiary. *Anguilla leptoptera* occurs in the Eocene of Monte Bolea, and *Anguilla elegans* in the Miocene of Œningen in Baden. Other fossil eels seem to belong to the *Nettastomidæ* and *Myridæ*.

Pug-nosed Eels.—Allied to the true eel is the pug-nosed eel, *Simenchelys parasiticus*, constituting the family of *Simenchelyidæ*. This species is scaled like a true eel, has a short,

blunt nose, and burrows its way into the bodies of halibut and other large fishes. It has been found in Newfoundland and

Fig. 103.—Pug-nosed Eel, *Simenchelys parasiticus* Gill. Sable Island Bank.

Madeira. Another family possessing rudimentary scales is that of the *Synaphobranchidæ*, slender eels of the ocean depths, widely distributed. In these forms the gill-openings are confluent. *Synaphobranchus pinnatus* is the best-known species.

Fig. 104.—*Synaphobranchus pinnatus* (Gronow). Le Have Bank.

Conger-eels. — The *Leptocephalidæ*, or conger-eels, are very similar to the fresh-water eels, but are without scales and with a somewhat different mouth, the dorsal beginning nearer to the head.

The principal genus is *Leptocephalus*, including the common conger-eel (*Leptocephalus conger*) of eastern America and Europe and numerous very similar species in the tropics of both continents. These fishes are strictly marine and, reaching the length of five or six feet, are much valued as food. The eggs are much larger than those of the eel and are produced in great numbers, so that the female almost bursts with their numbers. Dr. Hermes calculated that 3,300,000 were laid by one female in an aquarium.

These eggs hatch out into transparent band-like larva, with very small heads formerly known as *Leptocephalus*, an ancient name which is now taken for the genus of congers, having

been first used for the larva of the common conger-eel. The loose watery tissues of these "ghost-fishes" grow more and more compact and they are finally transformed into young congers.

FIG. 105.—Conger-eel, *Leptocephalus conger* (L.). Noank, Conn.

The *Murænesocidæ* are large eels remarkable for their strong knife-like teeth. *Murænesox savanna* occurs in the West Indies and in the Mediterranean, *Murænesox cinereus* in Japan, and *Murænesox coniceps* on the west coast of Mexico, all large

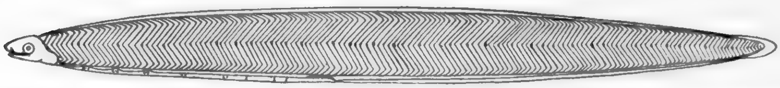


FIG. 106.—Larva of Conger-eel (*Leptocephalus conger*), called *Leptocephalus morrissi*. (After Eigenmann.)

and fierce, with teeth like shears. The *Myridæ* are small and worm-like eels closely allied to the congers, having the tail surrounded by a fin, but the nostrils labial. *Myrus myrus* is found in the Mediterranean. Species of *Eomyrus*, *Rhynchorhinus*, and *Paranguilla* apparently allied to *Myrus* occur in the Eocene. Other related families, mostly rare or living in the deep seas, are the *Ilyophidæ*, *Heterocongridæ*, and *Dysommidæ*.

The Snake-eels.—Most varied of the families of eels is the *Ophichthyidæ*, snake-like eels recognizable by the form of the tail, which protrudes beyond the fins. Of the many genera found in tropical waters several are remarkable for the sharply defined coloration, suggesting that of the snake. Characteristic species are *Chlevastes colubrinus* and *Leiuranus semicinctus*, two beautifully banded species of Polynesia, living in the same holes in the reefs and colored in the same fashion. Another is *Calle-*

chelys melanotænia. The commonest species on the Atlantic coast is the plainly colored *Ophichthus gomesi.*

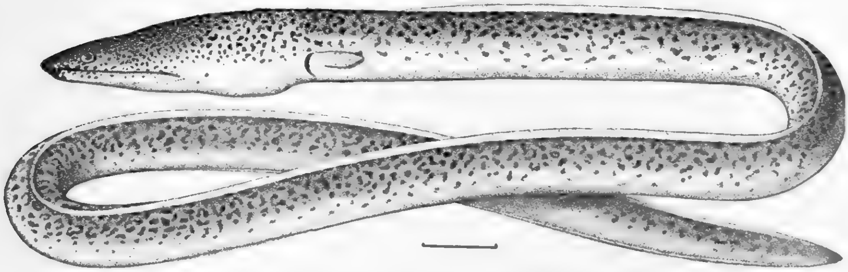


Fig. 107.—*Xyrias revulsus* Jordan & Snyder. Family *Ophichthyidæ.* Misaki, Japan.

In the genus *Sphagebranchus,* very slender eels of the reefs, the fins are almost wanting.

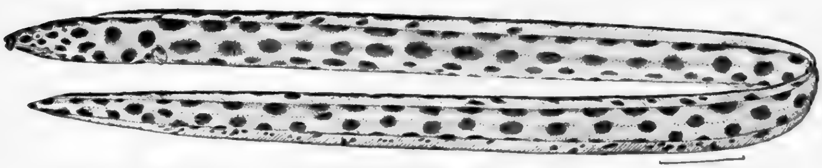


Fig. 108.—*Myrichthys pantostigmius* Jordan & McGregor. Clarion Island.

Allied to the Congers is the small family of duck-billed eels (*Nettastomidæ*) inhabiting moderate depths of the sea. *Nettastoma bolcense* occurs in the Eocene of Monte Bolca. The produced snout forms a transition to the really extraordinary type of thread-eels or snipe-eels (*Nemichthyidæ*), of which numerous genera and species live in the oceanic depths. In *Nemichthys*

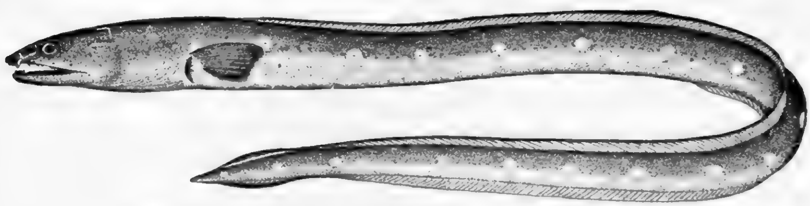


Fig. 109.—*Ophichthus ocellatus* (Le Sueur). Pensacola.

the long, very slender, needle-like jaws are each curved backward so that the mouth cannot by any possibility be shut. The body is excessively slender and the fish swims with swift undulations, often near the surface, and when seen is usually

taken for a snake. The best-known species is *Nemichthys scolopaceus* of the Atlantic and Pacific. *Nemichthys avocetta*, very much like it, has been twice taken in Puget Sound.

Suborder Colocephali, or Morays. — In the suborder *Colocephali* (κολός, deficient; κεφαλή, head) the palatopterygoid arch and the membrane-bones generally are very rudimentary. The skull is thus very narrow, the gill-structures are not well developed, and in the chief family there are no pectoral fins. This group is very closely related to the *Enchelycephali*, from which it is probably derived.

In the great family of morays (*Murænidæ*) the teeth are often very highly developed. The muscles are always very strong and the spines bite savagely, a live moray being often able to drive men out of a boat. The skin is thick and leathery, and the coloration is highly specialized, the pattern of color being often

Fig. 110.

Fig. 111.

Fig. 110.—Thread-eel, *Nemichthys avocetta* Jordan & Gilbert. Vancouver Island.
Fig. 111.—Jaws of *Nemichthys avocetta* Jordan & Gilbert.

elaborate and brilliant. In *Echidna zebra* for example the body is wine-brown, with cross-stripes of golden yellow. In *Muræna* each nostril has a barbel. *Muræna helena*, the oldest moray known, is found in Europe. In *Gymnothorax*, the largest genus, only the anterior nostrils are thus provided. *Gymnothorax mordax* of California is a large food-fish, as are also the brown *Gymnothorax funebris* and the spotted *Gymnothorax moringa* in the West Indies. These and many other species may coil themselves in crevices in the reefs, whence they strike out at their prey like snakes, taking perhaps the head of a duck or the finger of a man.

In many of the morays the jaws are so curved and the mouth so filled with knife-like teeth that the jaws cannot be closed. This fact, however, renders no assistance to their prey, as the teeth are adapted for holding as well as for cutting.

In *Enchelynassa bleekeri*, a huge wine-colored eel of the South Seas, the teeth are larger than in any other species. *Evenchelys*

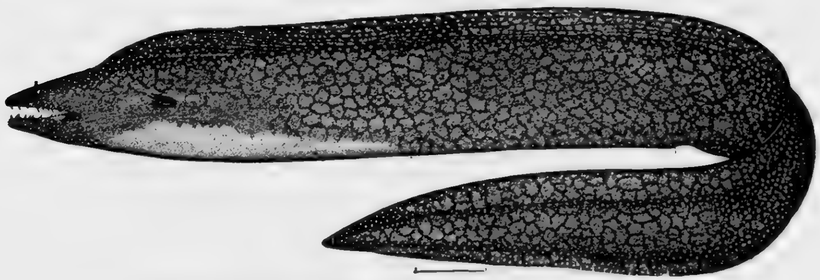


FIG. 112.—*Muræna retifera* Garman. Charleston, S. C.

(*macrurus*) is remarkable for its extraordinary length of tail, *Echidna* for its blunt teeth, and *Scuticaria*, *Uropterygius*, and *Channomuræna* for the almost complete absence of fins. In *Anarchias* (*allardicei; knighti*), the anal fin is absent. The flesh of the morays is rather agreeable in taste, but usually oily and not readily digestible, less wholesome than that of the true eels.

The *Myrocongridæ* are small morays with developed pectoral fins. The species are few and little known.

Family Moringuidæ.—Structurally one of the most peculiar of the groups of eels is the small family of *Moringuidæ* of the East and West Indies. In these very slender, almost worm-like fishes the heart is placed very far behind the gills and the tail is very short. The fins are very little developed, and some forms, as *Gordiichthys irretitus* of the Gulf of Mexico, the body as slender as a whiplash, possess a very great number of vertebræ. *Moringua hawaiiensis* occurs in Hawaii, *M. edwardsi* in the Bahamas. This family probably belongs with the morays to the group of *Colocephali*, although its real relationships are not wholly certain.

Order Carencheli, the Long-necked Eels.—Certain offshoots from the Apodes so widely diverging in structure that they must apparently be considered as distinct orders occur sparingly in the deep seas. One of these, *Derichthys serpentinus*, the

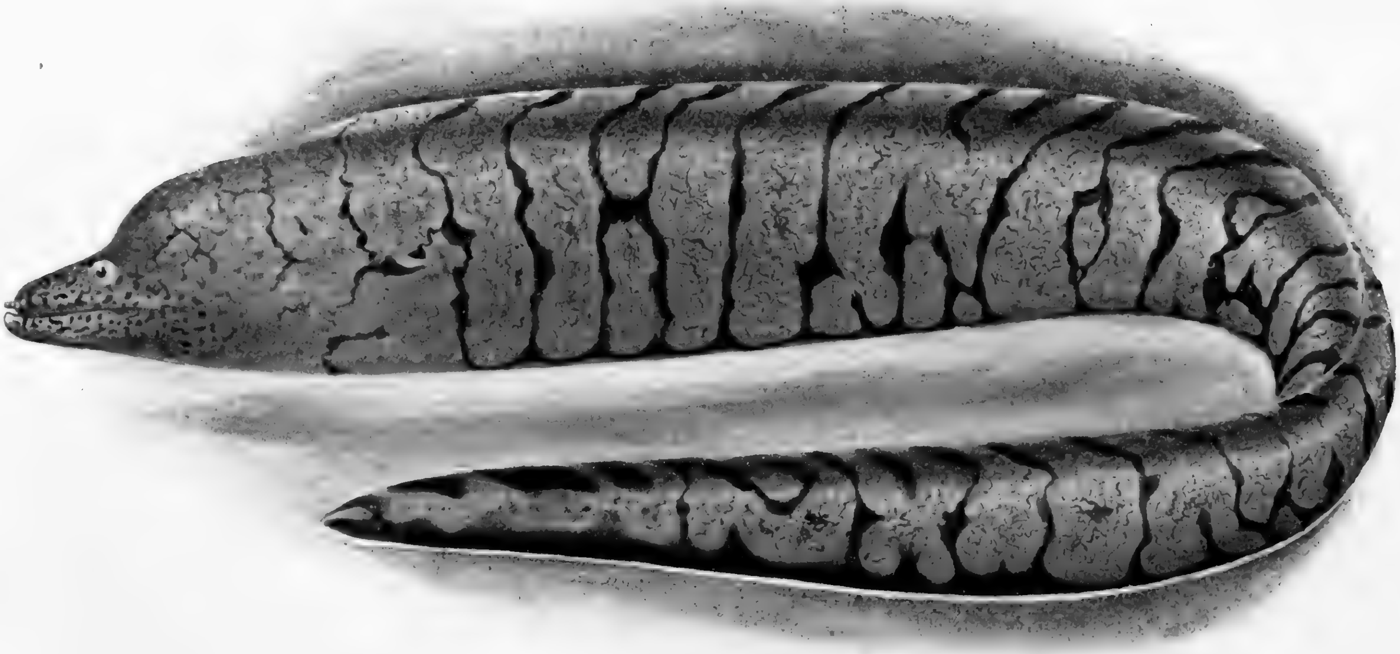


Fig. 113.—*Gymnothorax berndti* Snyder. Hawaii. Family *Murænidæ*.

long-necked eel, constitutes the sole known species of the suborder *Carencheli* (*καρά*, head; *ἔγχελυς*, eel). In this group the premaxillaries and maxillaries are present as in ordinary

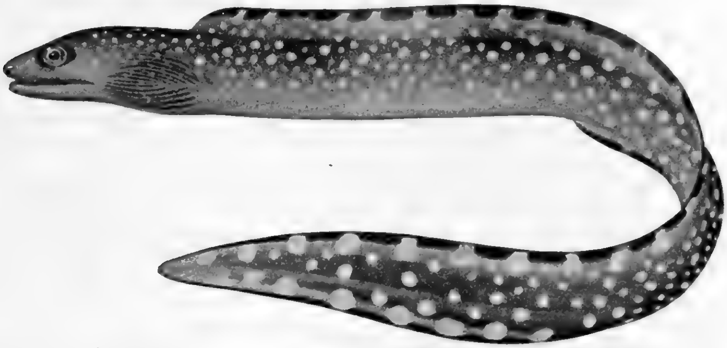


FIG. 114.—*Gymnothorax jordani* (Evermann & Marsh). Family *Murænidæ*. Puerto Rico.

fishes, but united by suture and soldered to the cranium. As in true eels, the shoulder-girdle is remote from the skull. The

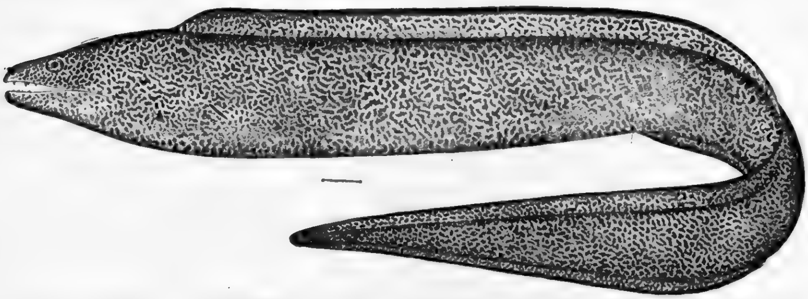


FIG. 115.—Moray, *Gymnothorax moringa* Bloch. Family *Murænidæ*. Tortugas.

head is set on a snake-like neck. The single species representing the family *Derichthyidæ* was found in the abysmal depths of the Gulf Stream.

Order Lyomeri, or Gulpers.—Still more aberrent and in many respects extraordinary are the eels of the order or suborder *Lyomeri* (*λυός*, loose; *μέρος*, part), known as "Gulpers." These are degenerate forms, possibly degraded from some conger-like type, but characterized by an extreme looseness of structure unique among fishes. The gill-arches are reduced to five small bars of bone, not attached to the skull; the palatopterygoid arch is wholly wanting, the premaxillaries are

wanting, as in all true eels, and the maxillaries loosely joined to the skull. The symplectic bone is wanting, and the lower jaw is so hinged to the skull that it swings freely in various directions. In place of the lateral line are singular appendages.

FIG. 116.—*Derichthys serpentinus* Gill. Gulf Stream.

Dr. Gill says of these fishes: "The entire organization is peculiar to the extent of anomaly, and our old conceptions of the characteristics of a fish require to be modified in the light of our knowledge of such strange beings." Special features are the extraordinary size of the mouth, which has a cavity larger than that of the rest of the body, the insertion of the very small eye at the tip of the snout, and the relative length of the tail. The whole substance is excessively fragile as usual with animals living in great depths and the color is jet black. Three species

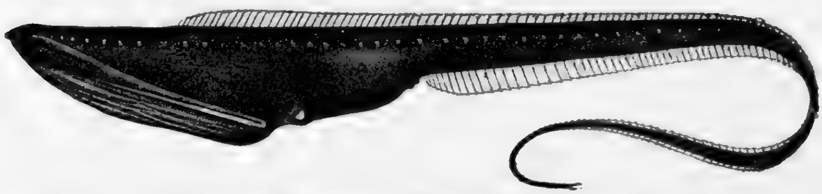


FIG. 117.—Gulper-eel, *Gastrostomus bairdi* Gill & Ryder. Gulf Stream.

have been described, and these have been placed in two families, *Saccopharyngidæ*, with the trunk (gill-opening to the vent) much longer than the head, and *Eurypharyngidæ*, with the trunk very short, much shorter than the head. The best-known species is the pelican eel (*Eurypharynx pelacanoides*), of the coast of Morocco, described by Vaillant in 1882. *Gastrostomus bairdi*, very much like it, occurs in the great depths under the Gulf Stream. So fragile and so easily distorted are these fishes that

it is possible that all three are really the same species, for which the oldest name would be *Saccopharynx ampullaceus*. Of this form four specimens have been taken in the Atlantic, one of them six feet long, carried to the surface through having swallowed fishes too large to be controlled. To be carried above its depth in a struggle with its prey is one of the greatest dangers to which the abysmal fishes are subject.

Order Heteromi.—The order of *Heteromi* (ἑτερός, different; ὦμος, shoulder), or spiny eels, may be here noticed for want of a better place, as its affinities are very uncertain. Some writers have regarded it as allied to the eels; some have placed it among the Ganoids. Others have found affinities with the stickle-backs, and still others with the singular fresh-water fishes called *Mastacembelus*. The *Heteromi* agree with the eels, as well as with *Mastacembelus*, in having the scapular arch separate from the cranium. Unlike all the true eels, most of the species have true dorsal and anal spines, as in the *Percesoces* and *Hemibranchii*. The ventral fins, when present, are abdominal and each with several spines in front, a character not found among the *Acanthopteri*. There is no mesocoracoid.

The air-bladder has a duct, and the coracoids, much as in the *Xenomi*, are reduced to a single lamellar imperforate plate. The two groups have little else in common, however, and this trait is possibly primitive in both cases, more likely to have arisen through independent degeneration. The separation of the shoulder-girdle doubtless indicates no affinity with the eels, as the bones of the jaws are quite normal. Two families are known, both from the deep sea, besides an extinct family in which spines are not developed.

The *Notacanthidæ* are elongate, compressed, ending in a band-shaped, tapering tail; the back has numerous free spines and few or no soft rays, and the mouth is normal, provided with teeth. The species of *Notacanthus* are few and scantily preserved. Those of *Macdonaldia* are more abundant. *Macdonaldia challengeri* is from the North Pacific, being once taken off Tokio. The extinct family of *Protonotacanthidæ* differs in the total absence of dorsal spines and fin-rays; the single species, *Pronotocanthus sahel-almæ*, originally described as a primitive eel, occurs in the Cretaceous of Mount Lebanon.

The *Lipogenyidæ* have a round, sucker-like mouth, with imperfect lower jaw, but are otherwise similar. *Lipogenys gilli* was dredged in the Gulf Stream.

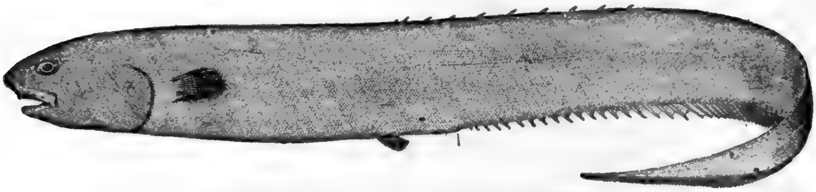


FIG. 118.—*Notacanthus phasganorus* Goode & Bean. Grand Banks.

Dr. Boulenger has recently extended the group of *Heteromi* by the addition of the *Dercetidæ*, *Halosauridæ* (*Lyopomi*), and the *Fierasferidæ*. We can hardly suppose that all these forms are really allied to *Notacanthus*.

CHAPTER VIII

SERIES OSTARIOPHYSI

OSTARIOPHYSI.—A large group of orders, certainly of common descent, may be brought together under the general name of *Ostariophysi* (ὀσταρίον, a small bone; θυσός, inflated). These are in many ways allied to the *Isospondyli*, but they have undergone great changes of structure, some of the species being highly specialized, others variously degenerate. A chief character is shared by all the species. The anterior vertebræ are enlarged, interlocked, considerably modified, and through them a series of small bones connect the air-bladder with the ear. The air-bladder thus becomes apparently an organ of hearing through a form of connection which is lost in all the higher fishes.

In all the members of this group excepting perhaps the degraded eel-like forms called *Gymnonoti*, the mesocoracoid arch persists, a trait found in all the living types of Ganoids, as well as in the *Teleost* order of *Isospondyli*. Other traits of the Ostariophysan fishes are shared by the *Isospondyli* (herring, salmon) and other soft-rayed fishes. The air-bladder is large, but not cellular. It leads through life by an open duct to the œsophagus. The ventral fins are abdominal in position. The pectorals are inserted low. A mesocoracoid arch is developed on the inner side of the shoulder-girdle. (See Fig. 119.) There are no spines on the fins, except in many cases a single one, a modified soft ray at front of dorsal or pectoral. The scales, if present, are cycloid or replaced by bony plates.

Many of the species have an armature much like that of the sturgeon, but here the resemblance ends, the bony plates in the two cases being without doubt independently evolved. According to Cope, the affinities of the catfishes to the sturgeon are "seen in the absence of symplectic, the rudimentary maxillary

bone, and, as observed by Parker, in the interclavicles. There is also a superficial resemblance in the dermal bones." But it is not likely that any real affinity exists.

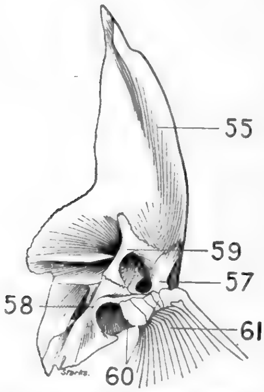


FIG. 119. — Inner view of shoulder-girdle of the Buffalo-fish. *Ictiobus bubalus* Rafinesque, showing the mesocoracoid (59). (After Starks.)

The sturgeons lack the characteristic auditory ossicles, or "Weberian apparatus," which the catfishes possess in common with the carp family, the *Characins*, and the *Gymnonoti*. These orders must at least have a common origin, although this origin is obscure, and fossil remains give little help to the solution of the problem. Probably the ancestors of the *Ostariophysi* are to be found among the allies of the *Osteoglossidæ*. Gill has called attention to the resemblance of *Erythrinus* to *Amia*. In any event, all the *Ostariophysi* must be considered together, as it is not conceivable that so complex a structure as the Weberian apparatus should have been more than once independently evolved. The branchiostegals, numerous among the *Isospondyli*, are mostly few among the *Ostariophysi*.

To the *Ostariophysi* belong the vast majority of the fresh-water fishes of the world. Their primitive structure is shown in

FIG. 120.—Weberian apparatus and air-bladder of Carp. (From Günther, after Weber.)

many ways; among others by the large number of vertebræ instead of the usual twenty-four among the more highly specialized families of fishes. We may group the *Ostariophysi* under

four orders: *Heterognathi*, *Eventognathi* (*Plectospondyli*), *Nematognathi*, and *Gymnonoti*.

The Heterognathi.—Of these the order of *Heterognathi* seems to be the most primitive, but in some ways the most highly developed, showing fewer traits of degeneration than any of the others. The presence of the adipose fin in this group and in the catfishes seems to indicate some sort of real affinity with the salmon-like forms, although there has been great change in other regards.

The order *Heterognathi*, or *Characini* (ἕτερος, different; γνάθος, jaw), contains those *Ostariophysi* which retain the mesocoracoid and are not eel-like, and which have the lower pharyngeals developed as in ordinary fishes. In most cases an adipose fin is present and there are strong teeth in the jaws. There are no pseudobranchiæ, and, as in the *Cyprinidæ*, usually but three branchiostegals. The *Characidæ* constitute the majority of the fresh-water fishes in those regions which have neither *Cyprinidæ* nor *Salmonidæ*. Nearly four hundred species are known from the rivers of South America and Africa. A single species, *Tetragonopterus argentatus*, extends its range northward to the Rio Grande in Texas. None are found in Asia, Europe, or, with this single exception, in the United States. Most of them are small fishes with deep bodies and very sharp, serrated, incisor-like teeth. Some are as innocuous as minnows, which they very much resemble, but others are extremely voracious and destructive in the highest degree. Of the caribe, belonging to the genus *Serrasalmo*, known by its serrated belly, Dr. Günther observes:

"Their voracity, fearlessness and number render them a perfect pest in many rivers of tropical America. In all the teeth are strong, short, sharp, sometimes lobed incisors, arranged in one or more series; by means of them they cut off a mouthful of flesh as with a pair of scissors; and any animal falling into the water where these fish abound is immediately attacked and cut to pieces in an incredibly short time. They assail persons entering the water, inflicting dangerous wounds before the victims are able to make their escape. In some localities it is scarcely possible to catch fishes with the hook and line, as the fish hooked is immediately attacked by the 'caribe' (as

these fish are called), and torn to pieces before it can be withdrawn from the water. The caribes themselves are rarely hooked, as they snap the hook or cut the line. The smell of blood is said to attract at once thousands of these fishes to the spot."

Two families of *Heterognathi* are recognized: the *Erythrinidæ*, which lack the adipose fin, and the *Characidæ*, in which this fin is developed. The *Erythrinidæ* are large pike-like fishes of the South American rivers, robust and tenacious of life, with large mouths armed with strong unequal teeth. The best-known species is the *Trahira* (*Hoplias malabaricus*).

Among the *Characidæ*, *Serrasalmo* has been already noticed. *Citharinus* in Africa has very few teeth, and *Curimatus* in South America none at all. *Nannocharax* in Africa is composed of

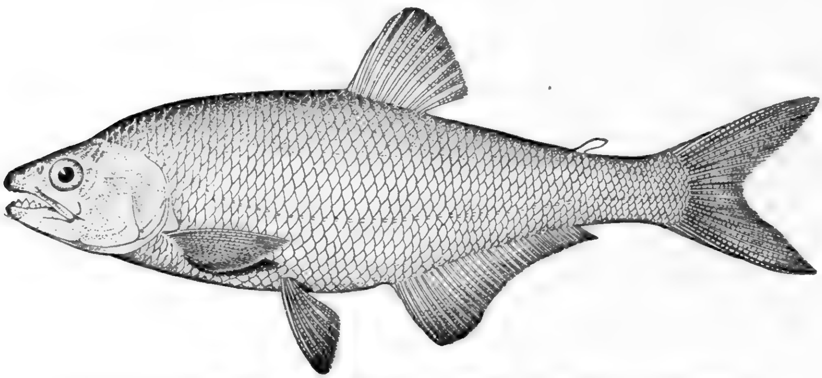


FIG. 121.—*Brycon dentex* Günther. Family *Characidæ*. Nicaragua.

very diminutive fishes, *Hydrocyon* exceedingly voracious ones, reaching a length of four feet, with savage teeth. Many of the species are allies of *Tetragonopterus*, small, silvery, bream-like fishes with flat bodies and serrated incisor teeth. Most of these are American. A related genus is *Brycon*, found in the streams about the Isthmus of Panama.

Extinct *Characins* are very rare. Two species from the Tertiary lignite of São Paulo, Brazil, have been referred to *Tetragonopterus*—*T. avus* and *T. ligniticus*.

The Eventognathi.—The *Eventognathi* (εὖ, well; ἔν, within; γνάθος, jaw) are characterized by the absence of teeth in the jaws and by the high degree of specialization of the lower phar-

yngeals, which are scythe-shaped and in typical forms are armed with a relatively small number of highly specialized teeth of peculiar shape and arranged in one, two, or three rows. In all the species the gill-openings are restricted to the sides; there is no adipose fin, and the broad, flat branchiostegals are but three in number. In all the species the scales, if present, are cycloid, and the ventral fins, of course, abdominal. The modification of the four anterior vertebræ and their connection with the air bladder are essentially as seen in the catfishes.

The name *Plectospondyli* is often used for this group (πλεκτός, interwoven; σπόνδυλος, vertebra), but that term originally included the *Characins* as well.

The Cyprinidæ.—The chief family of the *Eventognathi* and the largest of all the families of fishes is that of *Cyprinidæ*, comprising

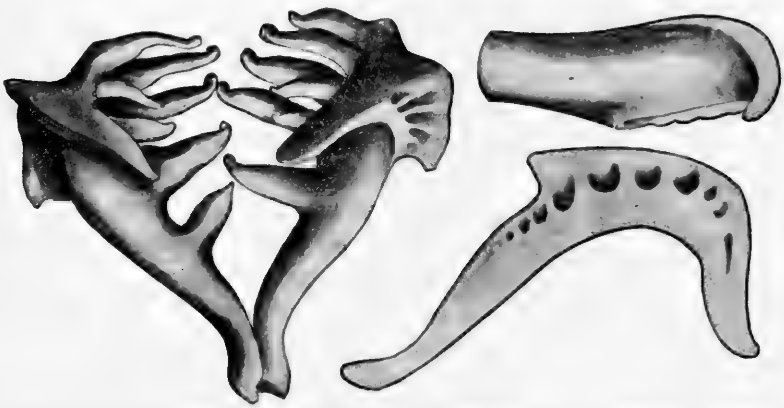


Fig. 122.—Pharyngeal bones and teeth of European Chub, *Leuciscus cephalus* (Linnæus). (After Seelye.)

200 genera and over 2000 species, found throughout the north temperate zone but not extending to the Arctic Circle on the north, nor much beyond the Tropic of Cancer on the south. In this family belong all the fishes known as carp, dace, chub, roach, bleak, minnow, bream, and shiner. The essential character of the family lies in the presence of one, two, or three rows of highly specialized teeth on the lower pharyngeals, the main row containing 4, 5, 6, or 7 teeth, the others 1 to 3. The teeth of the main row differ in form according to the food of the fish. They may be coarse and blunt, molar-like in those which feed on shells;

they may be hooked at tip in those which eat smaller fishes; they may be serrated or not; they may have an excavated "grinding surface," which is most developed in the species which feed on mud and have long intestines. In the *Cyprinidæ*, or carp family, the barbels are small or wanting, the head is naked, the caudal fin forked, the mouth is toothless and without sucking lips, and the premaxillaries form its entire margin. With a few exceptions the *Cyprinidæ* are small and feeble fishes. They form most of the food of the predatory river fishes, and their great abundance in competition with these is due to their fecundity and their insignificance. They spawn profusely and find everywhere an abundance of food. Often they check the increase of predatory fish by the destruction of their eggs.

In many of the genera the breeding color of the males is very brilliant, rendering these little creatures for a time the most beautifully colored of fishes. In spring and early summer the fins, sides, and head in the males are often charged with pigment, the prevailing color of which is rosy, though often satin-white, orange, crimson, yellow, greenish, or jet black. Among American genera *Chrosomus*, *Notropis*, and *Rhinichthys* are most highly colored. *Rhodeus*, *Rutilus*, and *Zacco* in the Old World are also often very brilliant.

In very many species, especially in America, the male in the breeding season is often more or less covered with small,

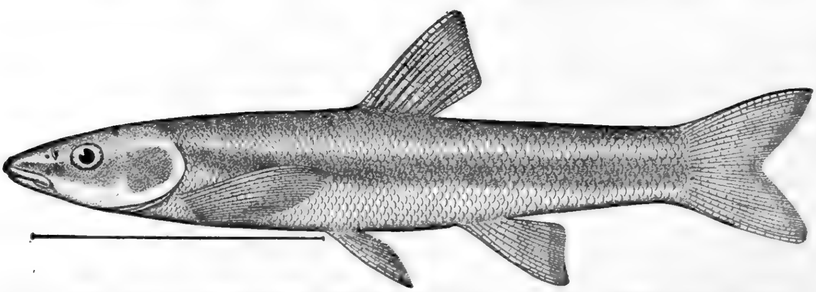


Fig. 123.—Black-nosed Dace, *Rhinichthys dulcis* Girard. Yellowstone River.

grayish tubercles or pearly bodies, outgrowths of the epidermis. These are most numerous on the head and fall off after the breeding season. They are most developed in *Campostoma*.

The *Cyprinidæ* are little valued as food-fishes. The carp, largely domesticated in small ponds for food, is coarse and

tasteless. Most of the others are flavorless and full of small bones. One species, *Opsariichthys uncirostris*, of Japan is an exception in this regard, being a fish of very delicate flavor.

In America 225 species of *Cyprinidæ* are known. One hundred of these are now usually held to form the single genus

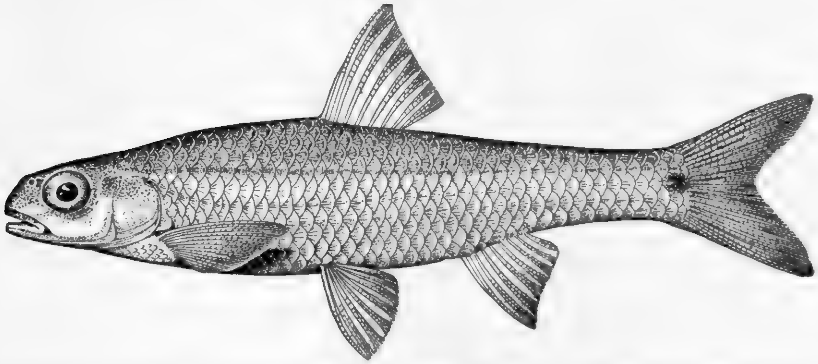


FIG. 124.—White Chub, *Notropis hudsonius* (Clinton). Kilpatrick Lake, Minn.

Notropis. This includes the smaller and weaker species, from two to seven inches in length, characterized by the loss, mostly through degeneration, of special peculiarities of mouth, fins, and teeth. These have no barbels and never more than four teeth

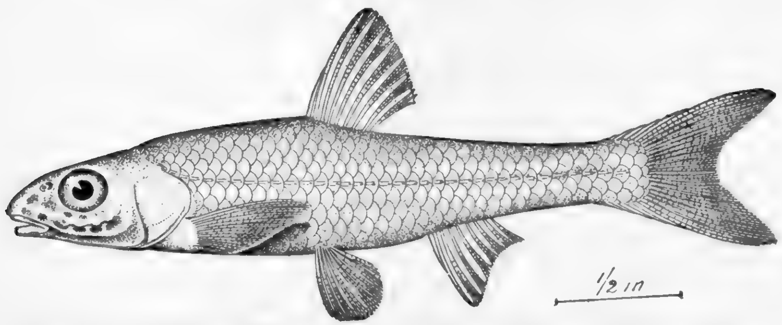


FIG. 125.—Silver-jaw Minnow, *Ericymba buccata* Cope. Defiance, Ohio.

in the main row. Few, if any, Asiatic species have so small a number, and in most of these the maxillary still retains its rudimentary barbel. But one American genus (*Orthodon*) has more than five teeth in the main row and none have more than two rows or more than two teeth in the lower row. By these and other peculiarities it would seem that the American species are at once less primitive and less complex than the Old World

forms. There is some evidence that the group is derived from Asia through western America, the Pacific Coast forms being much nearer the Old World types than the forms inhabiting the Mississippi Valley. Not many *Cyprinidæ* are found in Mexico, none in Cuba, South America, Australia, Africa, or the islands to the eastward of Borneo. Many species are very widely distributed, many others extremely local. In the genus *Notropis*, each river basin in the Southern States has its series of different and mostly highly colored species. The presence of *Notropis niveus* in the Neuse, *Notropis pyrrhomelas* in the Santee, *Notropis zonistius* in the Chattahoochee, *Notropis callistius*, *trichroistius*, and *stigmaturus* in the Alabama, *Notropis whipplei* in

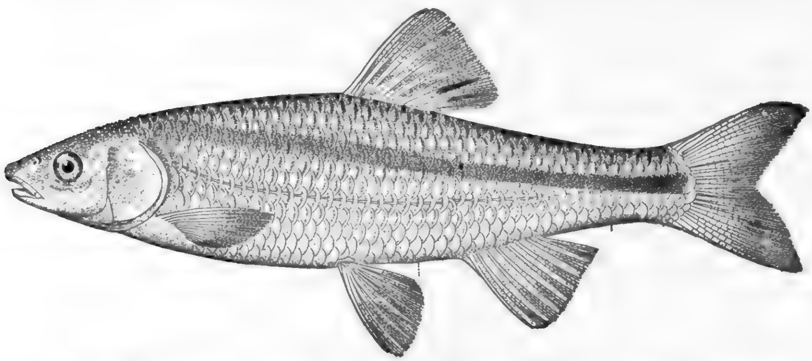


FIG. 126.—Silverfin, *Notropis whipplei* (Girard). White River, Indiana. Family *Cyprinidæ*.

the Mississippi, *Notropis galacturus* in the Tennessee, and *Notropis cercostigma* in the Sabine forms an instructive series in this regard. These fishes and the darters (*Etheostominæ*) are, among American fishes, the groups best suited for the study of local problems in distribution.

Species of Dace and Shiner.—Noteworthy species in other genera are the following:

Largest and best known of the species of *Notropis* is the familiar shiner or redfin, *Notropis cornutus*, found in almost every brook throughout the region east of the Missouri River.

Campostoma anomalum, the stone-roller, has the very long intestines six times the length of its body, arranged in fifteen coils around the air-bladder. This species feeds on mud and spawns in little brooks, swarming in early spring throughout

the Mississippi Valley, and is notable for its nuptial tubercles and the black and orange fins.

In the negro-chub, *Exoglossum maxillingua* of the Pennsyl-

FIG. 127.—Stone-roller, *Campostoma anomalum* (Rafinesque). Family *Cyprinidæ*. Showing nuptial tubercles and intestines coiled about the air-bladder.

vanian district, the rami of the lower jaw are united for their whole length, looking like a projecting tongue.

The fallfish, *Semotilus corporalis*, is the largest chub of the Eastern rivers, 18 inches long, living in swift, clear rivers. It is a soft fish, and according to Thoreau "it tastes like brown paper salted" when it is cooked. Close to this is the horned dace, *Semotilus atromaculatus*, and the horny head, *Hybopsis kentuckiensis*, both among the most widely distributed of our river fishes. These are all allied to the gudgeon (*Gobio gobio*), a common boys' fish of the rivers of Europe, and much sought by anglers who can get nothing better. The bream, *Abramis*, represented by numerous species in Europe, has a deep compressed body and a very long anal fin. It is also well represented in America, the golden shiner, common in Eastern and Southern streams, being *Abramis chrysoleucus*. The bleak of Europe (*Alburnus alburnus*) is a "shiner" close to some of our species of *Notropis*, while the minnow of Europe, *Phoxinus phoxinus*, resembles our gorgeously colored *Chrosomus erythro-*

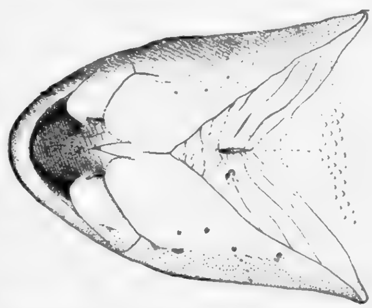


FIG. 128.—Head of Day-chub, *Exoglossum maxillingua* (Le Sueur). Shenandoah River.

gaster. Other European forms are the roach (*Rutilus rutilus*), the chub (*Leuciscus cephalus*), the dace (*Leuciscus leuciscus*),

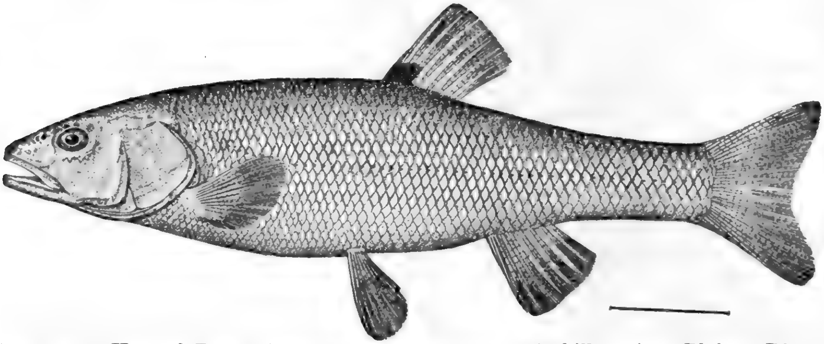


Fig. 129.—Horned Dace, *Semotilus atromaculatus* (Mitchill). Aux Plaines River, Ills. Family *Cyprinidæ*.

the id (*Idus idus*), the red-eye (*Scardinius erythropthalmus*), and the tench (*Tinca tinca*). The tench is the largest of the European species, and its virtues with those of its more or less

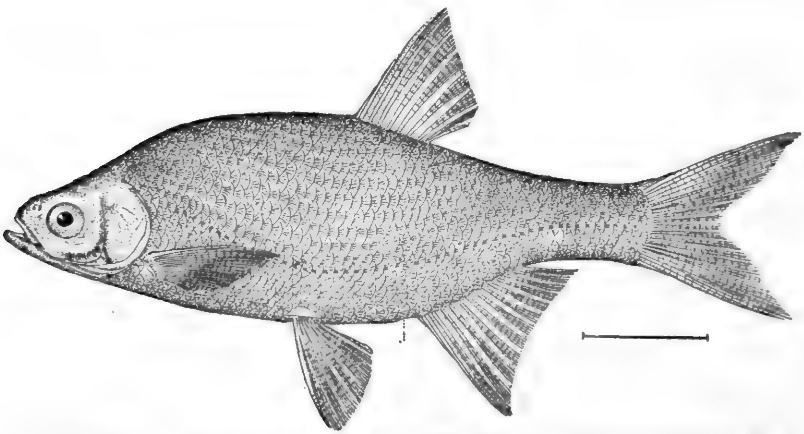


Fig. 130.—Shiner, *Abramis chrysoleucus* (Mitchill). Hackensack River, N. J.

insignificant allies are set forth in the pages of Izaak Walton. All of these receive more attention from anglers in England than their relatives receive in America. All the American *Cyprinidæ* are ranked as "boys' fish," and those who seek the trout or black bass or even the perch or crappie will not notice them. Thoreau speaks of the boy who treasures the yellow

perch as a real fish: "So many unquestionable fish he counts, then so many chubs which he counts, then throws away."

Chubs of the Pacific Slope.—In the Western waters are numerous genera, some of the species reaching a large size. The species

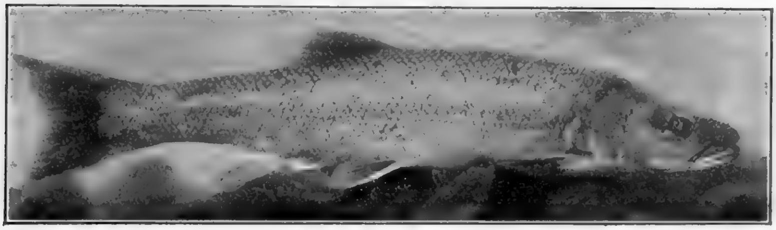


FIG. 131.—The Squawfish, *Ptychocheilus grandis* Agassiz. (Photograph by Cloudsley Rutter.)

of squawfish (*Ptychocheilus lucius* in the Colorado, *Ptychocheilus grandis* in the Sacramento, and *Ptychocheilus oregonensis* in the Columbia) reach a length of 4 or 5 feet or even more. These fishes are long and slender, with large toothless mouths and the aspect of a pike.

Allied to these are the "hard tails" (*Gila elegans* and *Gila robusta*) of the Colorado Basin, strange-looking fishes scarcely eatable, with lean bodies, flat heads, and expanded tails. The split-tail, *Pogonichthys macrolepidotus*, is found in the Sacramento.

In the chisel-mouth, *Acrocheïlus alutaceus*, of the Columbia the lips have a hard cutting edge. In *Meda*, very small fishes

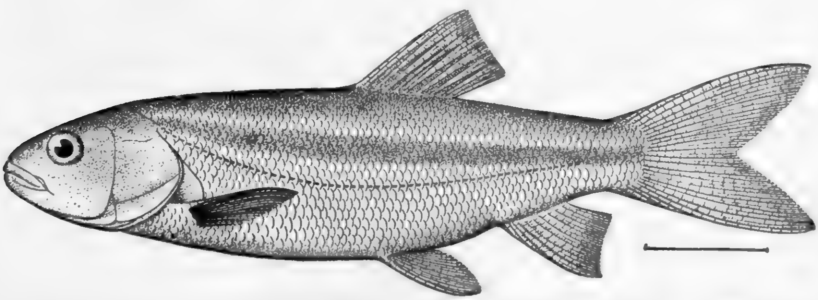


FIG. 132.—Chub of the Great Basin, *Leuciscus lineatus* (Girard). Heart Lake, Yellowstone Park. Family *Cyprinidæ*.

of the Colorado Basin, the dorsal has a compound spine of peculiar structure. Many of the species of Western waters belong to the genus *Leuciscus*, which includes also many species

of Asia and Europe. The common Japanese dace (*Leuciscus hakuensis*) is often found out in the sea, but, in general, *Cyprinidæ* are only found in fresh waters. The genus of barbels (*Barbus*) contains many large species in Europe and Asia. In these the barbel is better developed than in most other genera, a character which seems to indicate a primitive organization. *Barbus mosal* of the mountains of India is said to reach a length of more than six feet and to have "scales as large as the palm of the hand."

The Carp and Goldfish.—In the American and European *Cyprinidæ* the fin is few-rayed, but in many Asiatic species it is longer, having 15 to 20 rays and is often preceded by a serrated spine like that of a catfish. Of the species with long dorsal the one most celebrated is the carp (*Cyprinus carpio*). This fish is a native of the rivers of China, where it has been domesticated for centuries. Nearly three hundred years ago it was brought to northern Europe, where it has multiplied in domestication and become naturalized in many streams and ponds. Of late years the cultivation of the carp has attracted much attention in America. It has been generally satisfactory where the nature of the fish is understood and where expectations have not been too high.

The carp is a dull and sluggish fish, preferring shaded, tranquil, and weedy waters with muddy bottoms. Its food consists of water insects and other small animals, and vegetable matter, such as the leaves of aquatic plants. They can be fed on much the same things as pigs and chickens, and they bear much the same relation to trout and bass that pigs and chickens do to wild game and game-birds. The carp is a very hardy fish, grows rapidly, and has immense fecundity, 700,000 eggs having been found in the ovaries of a single individual. It reaches sometimes a weight of 30 to 40 pounds. As a food-fish the carp cannot be said to hold a high place. It is tolerated in the absence of better fish.

The carp, either native or in domestication, has many enemies. In America, catfish, sunfish, and pike prey upon its eggs or its young, as well as water-snakes, turtles, kingfishes, crayfishes, and many other creatures which live about our ponds and in sluggish streams. In domestication numerous varieties

of carp have been formed, the "leather-carp" (Lederkarpfen) being scaleless, others, "mirror-carp" (Spiegelkarpfen), having rows of large scales only along the lateral line or the bases of the fins.

Closely allied to the carp is the goldfish (*Carassius auratus*). This is also a common Chinese fish introduced in domestication into Europe and America. The golden-yellow color is found only in domesticated specimens, and is retained by artificial selection. The native goldfish is olivaceous in color, and where the species have become naturalized (as in the Potomac River, where it has escaped from fountains in Washington) it reverts to its natural greenish hue. The same change occurs in the rivers of Japan. The goldfish is valued solely for its bright colors as an ornamental fish. It has no beauty of form nor any interesting habits, and many of our native fishes (*Percidæ*, *Cyprinidæ*) far excel it in attractiveness as aquarium fishes. Unfortunately they are less hardy. Many varieties and monstrosities of the goldfish have been produced by domestication.

The Catostomidæ.—The suckers, or *Catostomidæ*, are an offshoot from the *Cyprinidæ*, differing chiefly in the structure of the mouth and of the lower pharyngeal bones. The border of the mouth above is formed mesially by the small premaxillaries and laterally by the maxillaries. The teeth of the lower pharyngeals are small and very numerous, arranged in one series like the teeth of a comb. The lips are usually thick and fleshy, and the dorsal fin is more or less elongate (its rays eleven to fifty in number), characters which distinguish the suckers from the American *Cyprinidæ* generally, but not from those of the Old World.

Fig. 133.—Lower pharyngeal of *Placopharynx duquesnii* (Le Sueur).

About sixty species of suckers are known, all of them found in the rivers of North America except two, which have been recorded on rather uncertain authority from Siberia and China. Only two or three of the species extend their range south of the Tropic of Cancer into Mexico or Central America, and none

occur in Cuba nor in any of the neighboring islands. The majority of the genera are restricted to the region east of the Rocky Mountains, although species of *Catostomus*, *Chasmistes*, *Deltistes*, *Xyrauchen*, and *Pantosteus* are found in abundance in the Great Basin and the Pacific slope.

In size the suckers range from six inches in length to about three feet. As food-fishes they are held in low esteem, the flesh of all being flavorless and excessively full of small bones. Most of them are sluggish fishes; they inhabit all sorts of streams, lakes, and ponds, but even when in mountain brooks they gather in the eddies and places of greatest depth and least current. They feed on insects and small aquatic animals, and also on mud, taking in their food by suction. They are not very tenacious of life. Most of the species swarm in the spring in shallow waters. In the spawning season they migrate up smaller streams than those otherwise inhabited by them. The

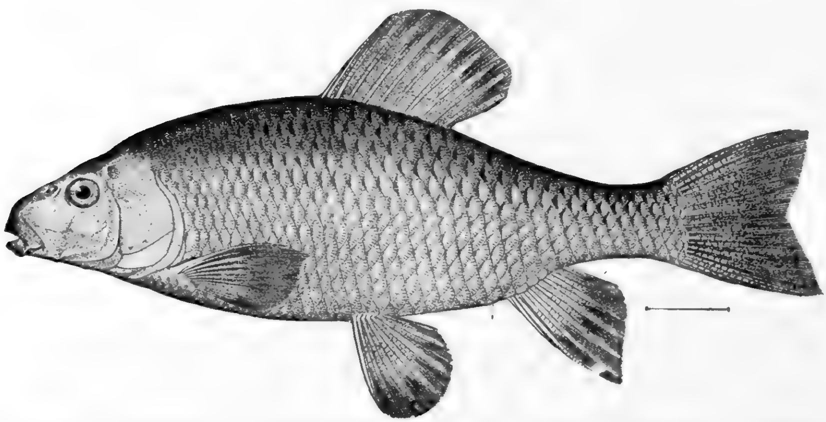


Fig. 134.—Creekfish or Chub-sucker, *Erimyzon sucetta* (Lacépède). Nipisink Lake, Illinois. Family *Catostomidæ*.

large species move from the large rivers into smaller ones; the small brook species go into smaller brooks. In some cases the males in spring develop black or red pigment on the body or fins, and in many cases tubercles similar to those found in the *Cyprinidæ* appear on the head, body, and anal and caudal fins.

The buffalo-fishes and carp-suckers, constituting the genera *Ictiobus* and *Carpiodes*, are the largest of the *Catostomidæ*, and

bear a considerable resemblance to the carp. They have the dorsal fin many rayed and the scales large and coarse. They

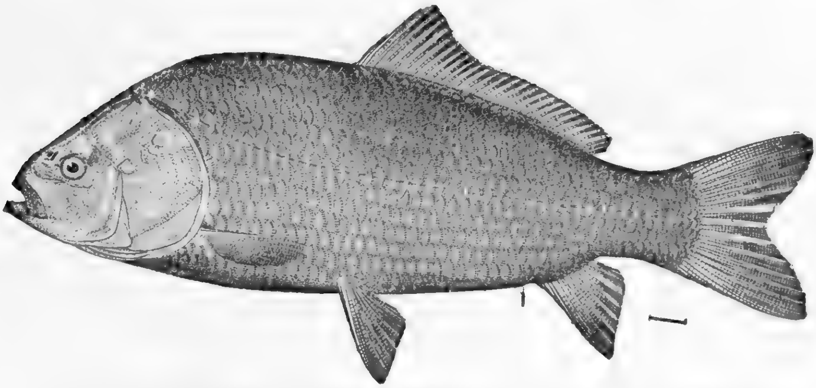


FIG. 135.—Buffalo-fish, *Ictiobus cyprinella* (Cuv. & Val.). Normal, Ill.

abound in the large rivers and lakes between the Rocky Mountains and the Alleghanies, one species being found in Central America and a species of a closely related genus (*Myxocyprinus asiaticus*)

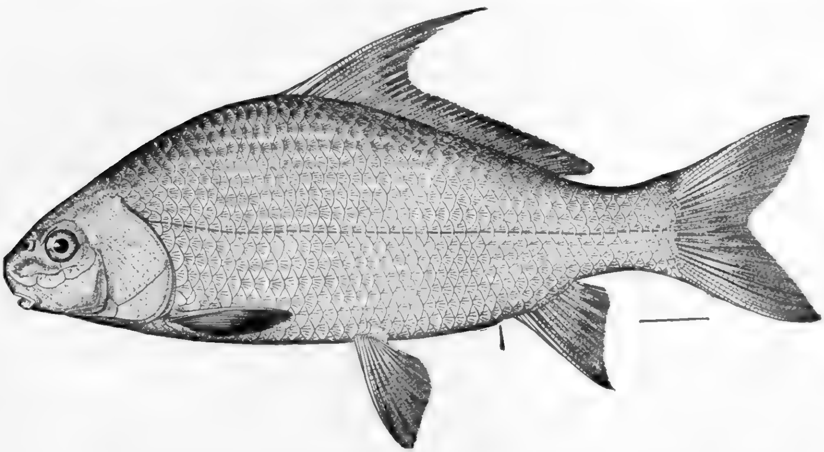


FIG. 136.—Carp-sucker, *Carpiodes cyprinus* (Le Sueur). Havre de Grace.

being reported from eastern Asia. They rarely ascend the smaller rivers except for the purpose of spawning. Although so abundant in the Mississippi Valley as to be of importance commerically, they are very inferior as food-fishes, being coarse and bony. The genus *Cycleptus* contains the black-horse, or Missouri sucker, a peculiar species with a small head, elongate

body, and jet-black coloration, which comes up the smaller rivers tributary to the Mississippi and Ohio in large numbers

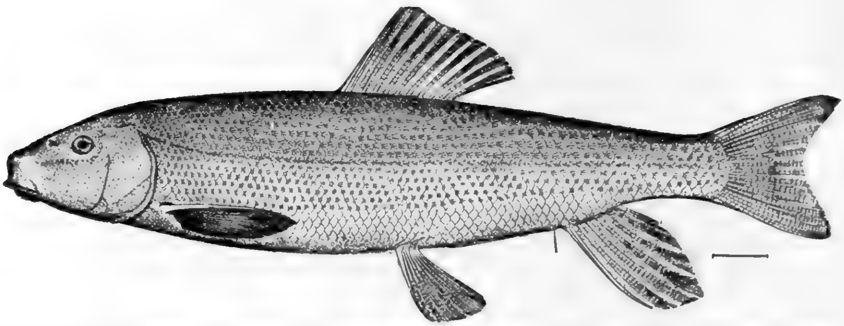


FIG. 137.—Common Sucker, *Catostomus commersoni* (Le Sueur). Ecorse, Mich.

in the spring. Most of the other suckers belong to the genera *Catostomus* and *Moxostoma*, the latter with the large-toothed *Placopharynx* being known, from the red color of the fins, as

FIG. 138.—California Sucker, *Catostomus occidentalis* Agassiz. (Photograph by Cloudsley Rutter.)

red-horse, the former as sucker. Some of the species are very widely distributed, two of them (*Catostomus commersoni*, *Erimyzon sucetta*) being found in almost every stream east of the Rocky Mountains and *Catostomus catostomus* throughout Canada to the Arctic Sea. The most peculiar of the suckers in appearance is the harelip sucker (*Quassilabia lacera*) of the Western rivers. Very singular in form is the hump-back or razor-back sucker of the Colorado, *Xyrauchen cypho*.

Fossil Cyprinidæ.—Fossil *Cyprinidæ*, closely related to existing forms, are found in abundance in fresh-water deposits of the Tertiary, but rarely if ever earlier than the Miocene. *Cyprinus*

priscus occurs in the Miocene of Germany, perhaps showing that Germany was the original home of the so-called "German carp," afterwards actually imported to Germany from China. Some specimens referred to *Barbus*, *Tinca*, *Rhodeus*, *Aspius*, and *Gobio* are found in regions now inhabited by these genera, and many species are referred to the great genus *Leuciscus*, *Leuciscus œningensis* from the Miocene of Germany being perhaps the best known. Several species of *Leuciscus* or related genera are found in the Rocky Mountain region. Among these is the recently described *Leuciscus turneri*.

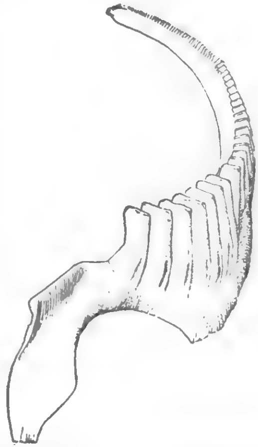


Fig. 139. — Pharyngeal teeth of Oregon Sucker, *Catostomus macrocheilus*.

Fossil *Catostomidæ* are very few and chiefly referred to the genus *Amyzon*, supposed to be allied to *Erimyzon*, but with a longer dorsal. *Amyzon commune* and other species are found in the Rocky Mountains, especially in the Miocene of the South Park in Colorado and the Eocene of Wyoming. Two or three species of *Catostomus*, known by their skulls, are found in the Pliocene of Idaho.

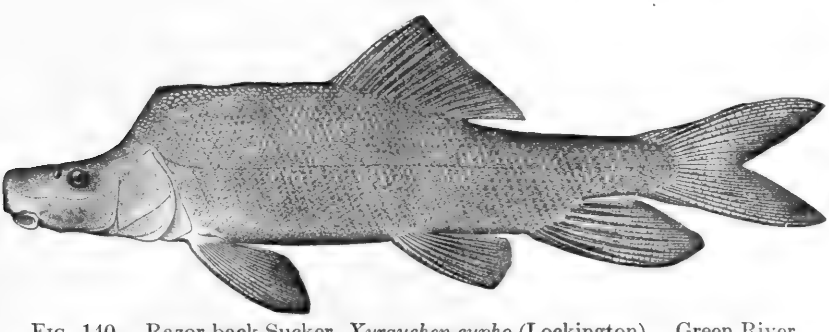


Fig. 140.—Razor-back Sucker, *Xyrauchen cypho* (Lockington). Green River, Utah.

The Loaches.—The *Cobitidæ*, or loaches, are small fishes, all less than a foot in length, inhabiting streams and ponds of Europe and Asia. In structure they are not very different from minnows, but they are rather eel-like in form, and the numerous

long barbels about the mouth strongly suggest affinity with the catfishes. The scales are small, the pharyngeal teeth few, and the air-bladder, as in most small catfishes, enclosed in a capsule. The loaches are all bottom fishes of dark colors, tenacious of life, feeding on insects and worms. The species often bury themselves in mud and sand. They lie quiet on the bottom and move very quickly when disturbed much after the manner of darters and gobies. Species of *Cobitis* and *Misgurnus* are widely distributed from England to Japan. *Nemachilus barbatulus* is the commonest European species. *Cobitis tænia* is found, almost unchanged, from England to the streams of Japan.

Remains of fossil loaches, mostly indistinguishable from *Cobitis*, occur in the Miocene and more recent rocks.

From ancestors of loaches or other degraded *Cyprinidæ* we may trace the descent of the catfishes.

The *Homalopteridæ* are small loaches in the mountain streams of the East Indies. They have no air-bladder and the number of pharyngeal teeth (10 to 16) is greater than in the loaches, carp, or minnows.

CHAPTER IX

THE NEMATOGNATHI, OR CATFISHES

THE Nematognathi.—The *Nematognathi* (νῆμα, thread; γνάθος, jaw), known collectively as catfishes, are recognized at once by the fact that the rudimentary and usually toothless maxillary is developed as the bony base of a long barbel or feeler. Usually other feelers are found around the head, suggesting the "smellers" of a cat. The body is never scaly, being either naked and smooth or else more or less completely mailed with bony plates which often resemble superficially those of a sturgeon. Other distinctive characters are found in the skeleton, notably the absence of the subopercle, but the peculiar development of the maxillary and its barbel with the absence of scales is always distinctive. The symplectic is usually absent, and in some the air-bladder is reduced to a rudiment inclosed in a bony capsule. In almost all cases a stout spine exists in the front of the dorsal fin and in the front of each pectoral fin. This spine, made of modified or coalescent soft rays, is often a strong weapon with serrated edges and capable of inflicting a severe wound. When the fish is alarmed, it sets this spine by a rotary motion in its socket joint. It can then be depressed only by breaking it. By a rotary motion upward and toward the body the spine is again lowered. The wounds made by this spine are often painful, but this fact is due not to a specific poison but to the irregular cut and to the slime of the spine.

In two genera, *Noturus* and *Schilbeodes*, a poison-gland exists at the base of the pectoral spine, and the wound gives a sharp pain like the sting of a hornet and almost exactly like the sting of a scorpion-fish. Most of the *Nematognathi* possess a fleshy or adipose fin behind the dorsal, exactly as in the salmon. In

a few cases the adipose fin develops an anterior spine and occasionally supporting rays.

All the *Nematognathi* are carnivorous bottom feeders, devouring any prey they can swallow. Only a few enter the sea, and they occur in the greatest abundance in the Amazon region. Upward of 1200 species, arranged in 150 genera, are recorded. They vary greatly in size, from two inches to six feet in length. All are regarded as food-fishes, but the species in the sea have very tough and flavorless flesh. Some of the others are extremely delicate, with finely flavored flesh and a grateful absence of small bones.

Families of Nematognathi.—According to Dr. Eigenmann's scheme of classification,* the most primitive family of Nematognathi is that of *Diplomystidæ*, characterized by the presence of a well-developed maxillary, as in other soft-rayed fishes. The single species, *Diplomystes papillosus*, is found in the waters of Chile.

Similar to the *Diplomystidæ* in all other respects is the great central family of *Siluridæ*, by far the most numerous and important of all the divisions of *Nematognathi*.

The Siluridæ.—This group has the skin naked or imperfectly mailed, the barbels on the head well developed, the dorsal short, inserted forward, the adipose fin without spine, and the lower pharyngeals separate. All the marine catfishes and most of the fresh-water species belong to this group, and its members, some 700 species, abound in all parts of the world where catfishes are known—"a bloodthirsty and bullying race of rangers inhabiting the river bottoms with ever a lance at rest and ready to do battle with their nearest neighbor."

The Sea Catfish.—In the tropical seas are numerous species of catfishes belonging to *Tachysurus*, *Arius*, *Galeichthys*, *Felichthys*, and other related genera. These are sleek, silvery fishes covered with smooth skin, the head usually with a coat of mail, pierced by a central fontanelle. Some of them reach a considerable size, swarming in sandy bays. None are valued as food, being always tough and coarsely flavored. Sea birds, as the pelican, which devour these catfishes are often destroyed by

* A Revision of the South American Nematognathi, 1890, p. 7.

the sudden erection of the pectoral spines. None of these are found in Europe or in Japan. Of the very many American species the gaff-topsail catfish (*Felichthys felis*), noted for its

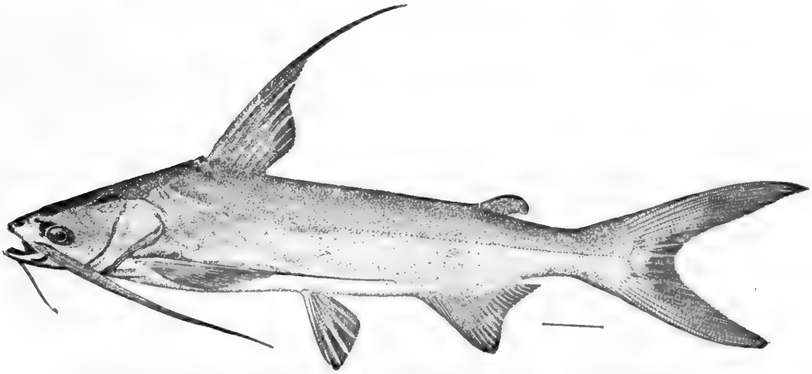


Fig. 141.—Gaff-topsail Cat, *Felichthys felis* (L.). Wood's Hole.

very high spines, extends farthest north and is one of the very largest species. This genus has two barbels at the chin. Most others have four. The commonest sea catfish of the Carolina coast is *Galeichthys milberti*. In *Tachysurus* the teeth

Fig. 142.—Sea Catfish, *Galeichthys milberti* (Cuv. & Val.). Pensacola.

on the palate are rounded, in most of the others they are in villiform bands.

In most or all of the sea catfish the eggs, as large as small peas, are taken into the mouth of the male and there cared for until hatched.

The Channel Cats.—In all the rivers of North America east of the Rocky Mountains are found catfishes in great variety. The channel cats, *Ictalurus*, known most readily by the forked tails, are the largest in size and most valued as food. The tech-

nical character of the genus is the backward continuation of the supraoccipital, forming a bony bridge to the base of the dorsal. The great blue cat, *Ictalurus furcatus*, abounds throughout the large rivers of the Southern States and reaches a weight of 150 pounds or more. It is an excellent food and its firm flesh is readily cut into steaks. In the Great Lakes and northward is a very similar species, also of large size, which has been called *Ictalurus*

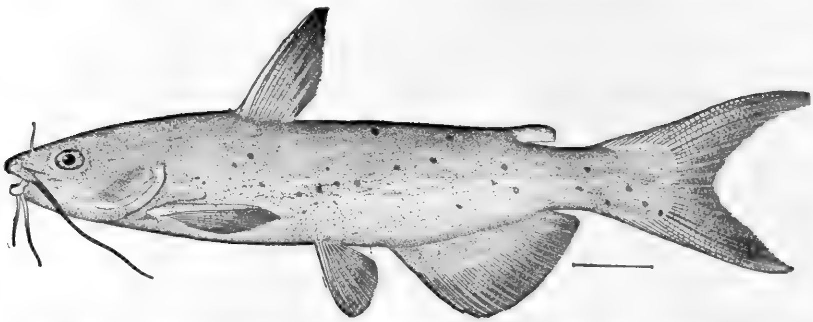


FIG. 143.—**Channel Catfish, *Ictalurus punctatus* (Rafinesque). Illinois River.** Family *Siluridæ*.

lacustris. Another similar species is the willow cat, *Ictalurus anguilla*. The white channel-cat, *Ictalurus punctatus*, reaches a much smaller size and abounds on the ripples in clear swift streams of the Southwest, such as the Cumberland, the Alabama, and the Gasconade. It is a very delicate food-fish, with tender white flesh of excellent flavor.

Horned Pout.—The genus *Ameiurus* includes the smaller brown catfish, horned pout, or bullhead. The body is more plump and the caudal fin is usually but not always rounded. The many species are widely diffused, abounding in brooks, lakes, and ponds. *Ameiurus nebulosus* is the best-known species, ranging from New England to Texas, known in the East as horned pout. It has been successfully introduced into the Sacramento, where it abounds, as well as its congener, *Ameiurus catus* (see Fig. 229, Vol. I), the white bullhead, brought with it from the Potomac. The latter species has a broader head and concave or notched tail. All the species are good food-fishes. All are extremely tenacious of life, and all are alike valued by the urchin, for they will bite vigorously at any sort of bait. All must be handled with care, for the sharp pectoral spines make an ugly cut, a species of

wound from which few boys' hands in the catfish region are often free.

In the caves about Conestoga River in Lancaster County, Pennsylvania, is a partly blind catfish, evidently derived from

FIG. 144.—Horned Pout, *Ameiurus nebulosus* (Le Sueur). (From life by Dr. R. W. Shufeldt.)

local species outside the cave. It has been named *Gronias nigrilabris*.

A few species are found in Mexico, one of them, *Ictalurus*

meridionalis, as far south as Rio Usamacinta on the boundary of Guatemala.

Besides these, a large channel-cat of peculiar dentition, known as *Istlarius balsanus*, abounds in the basin of Rio Balsas. In Mexico all catfishes are known as Bagre, this species as Bagre de Rio.

The genus *Leptops* includes the great yellow catfish, or goujon, known at once by the projecting lower jaw. It is a mottled olive and yellow fish of repulsive exterior, and it reaches a very great size. It is, however, a good food-fish.

The Mad-toms.—The genera *Noturus* and *Schilbeodes* are composed of diminutive catfishes, having the pectoral spine armed at base, with a poison sac which renders its sting ex-

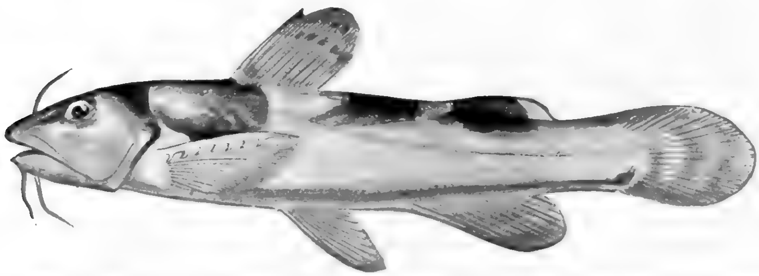


FIG. 145.—Mad-tom, *Schilbeodes furiosus* Jordan & Meek. Showing the poisoned pectoral spine. Family *Siluridæ*. Neuse River.

tremely painful though not dangerous. The numerous species of this genus, known as "mad-toms" and "stone cats," live among weeds in brooks and sluggish streams. Most of them rarely exceed three inches in length, and their varied colors make them attractive in the aquarium.

The Old World Catfishes.—In the catfishes of the Old World and their relatives, the adipose fin is rudimentary or wanting. The chief species found in Europe is the huge sheatfish, or wels, *Silurus glanis*. This, next to the sturgeon, is the largest river fish in Europe, weighing 300 to 400 pounds. It is not found in England, France, or Italy, but abounds in the Danube. It is a lazy fish, hiding in the mud and thus escaping from nets. It is very voracious, and many stories are told of the contents of its stomach. A small child swallowed whole is recorded from Thorn, and there are still more remarkable stories, but not

properly vouched for. The sheatfish is brown in color, naked, sleek, and much like an American *Ameiurus* save that its tail is much longer and more eel-like. Another large catfish, known to the ancients, but only recently rediscovered by Agassiz and Garman, is *Parasilurus aristotelis* of the rivers of Greece. In China and Japan is the very similar Namazu, or Japanese catfish, *Parasilurus asotus*, often found in ponds and used as food. Numerous smaller related catfishes, *Porcus* (*Bagrus*), *Pseudobagrus*, and related genera swarm in the brooks and ponds of the Orient.

In the genus *Torpedo* (*Malapterurus*) the dorsal fin is wanting. *Torpedo electricus*, the electric catfish of the Nile, is a species of much interest to anatomists. The shock is like that of a Leyden jar. The structures concerned are noticed on p. 186,

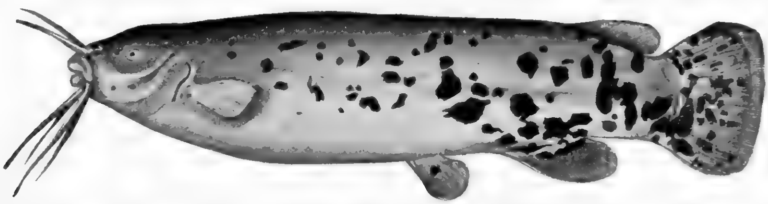


Fig. 146.—Electric Catfish, *Torpedo electricus* (Gmelin). Congo River. (After Boulenger.)

Vol. I. The generic name *Torpedo* was applied to the electric catfish before its use for the electric ray.

In South America a multitude of genera and species cluster around the genus *Pimelodus*. Some of them have the snout very long and spatulate. Most of them possess a very long adipose fin. The species are generally small in size and with smooth skin like the North American catfishes. Still other species in great numbers are grouped around the genus *Doras*. In this group the snout projects, bearing the small mouth at its end, and the lateral line is armed behind with spinous shields. All but one of the genera belong to the Amazon district, *Synodontis* being found in Africa.

Concerning *Doras*, Dr. Günther observes: "These fishes have excited attention by their habit of traveling during the dry season from a piece of water about to dry up in quest of a pond of greater capacity. These journeys are occasionally of such a length that the fish spends whole nights on the way,

and the bands of scaly travelers are sometimes so large that the Indians who happen to meet them fill many baskets of the prey thus placed in their hands. The Indians suppose that the fish carry a supply of water with them, but they have no special organs and can only do so by closing the gill-openings or by retaining a little water between the plates of their bodies, as Hancock supposes. The same naturalist adds that they make regular nests, in which they cover up their eggs with care and defend them, male and female uniting in this parental duty until the eggs are hatched. The nest is constructed, at the beginning of the rainy season, of leaves and is sometimes placed in a hole scooped out of the beach."

The Sisoridæ.—The *Sisoridæ* are small catfishes found in swift mountain streams of northern India. In some of the genera (*Pseudecheneis*) in swift streams a sucking-disk formed of longitudinal plates of skin is formed on the breast. This enables these fishes to resist the force of the water. In one genus, *Exostoma*, plates of skin about the mouth serve the same purpose.

The *Bunocephalidæ* are South American catfishes with the dorsal fin undeveloped and the top of the head rough. In *Platystacus* (*Aspredo*), the eggs are carried on the belly of the female, which is provided with spongy tentacles to which the eggs are attached. After the breeding season the ventral surface becomes again smooth.

The Plotosidæ.—The *Plotosidæ* are naked catfishes, largely marine, found along the coasts of Asia. In these fishes the second dorsal is very long. *Plotosus anguillaris*, the sea catfish of Japan, is a small species striped with yellow and armed with sharp pectoral spines which render it a very disagreeable object to the fishermen. In sandy bays like that of Nagasaki it is very abundant. Allied to this is the small Asiatic family of *Chacidæ*.

The Chlariidæ.—The *Chlariidæ* are eel-like, with a soft skeleton and a peculiar accessory gill. These abound in the swamps and muddy streams of India, where some species reach a length of six feet. One species, *Chlarias magur*, has been brought by the Chinese to Hawaii, where it flourishes in the same

waters as *Ameiurus nebulosus*, brought from the Potomac and by Chinese carried from San Francisco.

The Hypophthalmidæ and Pygidiidæ. — The *Hypophthalmidæ* have the minute air-bladder inclosed in a long bony capsule. The eyes are placed very low and the skin is smooth. The statement that this family lacks the auditory apparatus is not correct. The few species belong to northern South America.

Allied to this group is the family *Pygidiidæ* with a differently formed bony capsule and no adipose fin. The numerous species are all South American, mostly of mountain streams of high altitude. Some are very small. Certain species are said to flee for protection into the gill-cavity of larger cat-

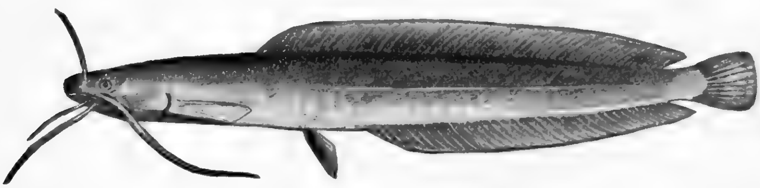


FIG. 147.—An African Catfish, *Chlarias breviceps* Boulenger. Congo River. Family *Chlariidæ*. (After Boulenger.)

fishes. Some are reported to enter the urethra of bathers, causing severe injuries. The resemblance of certain species to the loaches, or *Cobitidæ*, is very striking. This similarity is due to the results of similar environment and necessarily parallel habits. The *Argidæ* have the capsule of the air-bladder formed in a still different fashion. The few species are very small, inhabitants of the streams of the high Andes.

The Loricariidæ.—In the family of *Loricariidæ* the sides and back are armed with rough bony plates. The small air-bladder is still in a bony capsule, and the mouth is small with thick fringed lips. The numerous species are all small fishes of the South American waters, bearing a strong external resemblance to *Agonidæ*, but wholly different in anatomy.

The Callichthyidæ. — The *Callichthyidæ* are also small fishes armed with a bony interlocking coat of mail. They are closely allied to the *Pygidiidæ*. The body is more robust than in the *Callichthyidæ* and the coat of mail is differently formed. The species swarm in the rivers of northern South America, where

with the mailed *Loricariidæ* they form a conspicuous part of the fish fauna.

Fossil Catfishes.—Fossil catfishes are very few in number. *Siluridæ*, allied to *Chlarias*, *Bagarius*, *Heterobranchus*, and other fresh-water forms of India, are found in the late Tertiary rocks of Sumatra, and catfish spines exist in the Tertiary rocks of the United States. Vertebræ in the Canadian Oligocene have been referred by Cope to species of *Ameiurus* (*A. cancellatus* and *A. maconnelli*). *Rhineastes peltatus* and six other species, perhaps allied to *Pimelodus*, have been described by Cope from Eocene of Wyoming and Colorado. *Bucklandium diluvii* is found in the Eocene London clays, and several species apparently marine, referred to the neighborhood of *Tachysurus* or *Arius*, are found in Eocene rocks of England.

There is no evidence that the group of catfishes has any great antiquity, or that its members were ever so numerous and varied as at the present time. The group is evidently derived from scaly ancestors, and its peculiarities are due to specialization of certain parts and degeneration of others.

There is not the slightest reason for regarding the catfishes as direct descendants of the sturgeon or other Ganoid type. They should rather be looked upon as a degenerate and highly modified offshoot from the primitive Characins.

FIG. 148.—*Loricaria aurea* Steindachner, a mailed Catfish from Rio Meta, Venezuela. Family *Loricariidæ*. (After Steindachner.)

Order Gymnonoti.—At the end of the series of *Ostariophysans* we may place the *Gymnonoti* (*γυμνός*, bare; *νῶτος*, back). This group contains about thirty species of fishes from the rivers of South America and Central America. All are eel-like in form, though the skeleton with the shoulder-girdle suspended from the cranium is quite unlike that of a true eel. There is no dorsal fin. The vent is at the throat and the anal is excessively long. The gill-opening is small as in the eel, and as in most elongate fishes, the ventral fins are undeveloped. The body is naked or covered with small scales.

Two families are recognized, differing widely in appearance. The *Electrophoridæ* constitutes by itself Cope's order of *Glanencheli* (*γλανίς*, catfish; *ἔγχελυς*, eel). This group he regards as intermediate between the eel-like catfishes (*Chlarias*) and the true eels. It is naked and eel-shaped, with a short head and projecting lower jaw like that of the true eel. The single species, *Electrophorus electricus*, inhabits the rivers of Brazil, reaching a length of six feet, and is the most powerful of all electric fishes. Its electric organs on the tail are derived from modified muscular tissue. They are described on p. 170, Vol. I.

The *Gymnotidæ* are much smaller in size, with compressed scaly bodies and the mouth at the end of a long snout. The numerous species are all fishes without electric organs. *Eigenmannia humboldti* of the Panama region is a characteristic species. No fossil *Gymnonoti* are recorded.

CHAPTER X

THE SCYPHOPHORI, HAPLOMI, AND XENOMI

ORDER **Scyphophori.** — The *Scyphophori* (σκύφος, cup; φορέω, to bear) constitutes a small order which lies apparently between the *Gymnonoti* and the *Isospondyli*. Boulenger unites it with the *Isospondyli*. The species, about seventy-five in number, inhabit the rivers of Africa, where they are important as food-fishes. In all there is a deep cavity on each side of the cranium covered by a thin bony plate, the supertemporal bone. There is no symplectic bone, and the subopercle is very small or concealed. The gill-openings are narrow and there are no pharyngeal teeth. The air-bladder connects with the ear, but not apparently in the same way as with the *Ostariophysan* fishes, to which, however, the *Scyphophori* are most nearly related. In all the *Scyphophori* the body is oblong, covered with cycloid scales, the head is naked, there are no barbels, and the small mouth is at the end of a long snout. All the species possess a peculiar organ on the tail, which with reference to a similar structure in *Torpedo* and *Electrophorus* is held to be a degenerate electric organ. According to Günther, "it is without electric functions, but evidently representing a transitional condition from muscular substance to an electric organ. It is an oblong capsule divided into numerous compartments by vertical transverse septa and containing a gelatinous substance."

The Mormyridæ. — There are two families of *Scyphophori*. The *Mormyridæ* have the ordinary fins and tail of fishes and the *Gymnarchidæ* are eel-like, with ventrals, anal and caudal wanting. *Gymnarchus miloticus* of the Nile reaches a length of six feet, and it is remarkable as retaining the cellular structure of the air-bladder as seen in the garpike and bowfin. It doubtless serves as an imperfect lung.

The best-known genus of *Scyphophori* is *Mormyrus*. Species of this genus found in the Nile were worshiped as sacred by the ancient Egyptians and pictures of *Mormyrus* are often seen among the emblematic inscriptions. The Egyptians did not eat the *Mormyrus* because with two other fishes it was accused of having devoured a limb from the body of Osiris, so that Isis was unable to recover it when she gathered the scattered remains of her husband.

In *Mormyrus* the bones of the head are covered by skin, the snout is more or less elongated, and the tail is generally short and insignificant. One of the most characteristically eccentric species is *Gnathonemus curvirostris*, lately discovered by Dr. Boulenger from the Congo. Fossil *Mormyridæ* are unknown.

The Haplomi. — In the groups called *Iniomi* and *Lyopomi*, the mesocoracoid arch is imperfect or wanting, a condition

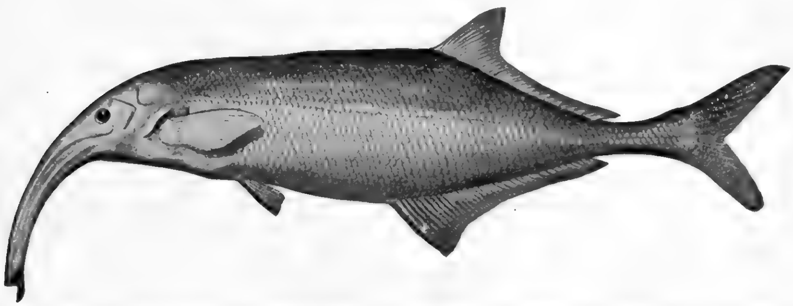


FIG. 149.—*Gnathonemus curvirostris* Boulenger. Family *Mormyridæ*. Congo River. (After Boulenger.)

which in some cases may be due to the degeneration produced by deep-sea life. In the eels a similar condition obtains. In the group called *Haplomi* (ἁπλοός, simple; ὦμος, shoulder), as in all the groups of fishes yet to be discussed, this arch is wholly wanting at all stages of development. In common with the *Isospondyli* and with soft-rayed fishes in general the air-bladder has a persistent air-duct, all the fins are without true spines, the ventral fins are abdominal, and the scales are cycloid. The group is a transitional one, lying almost equidistant between the *Isospondyli* and the *Acanthopterygii*. Gill unites it with the latter and Woodward with the former. We may regard it for the present

as a distinct order, although no character of high importance separates it from either. Hay unites the *Haplomi* with the *Synentognathi* to form the order of *Mesichthyes*, or transitional fishes, but the affinities of either with other groups are quite as well marked as their relation to each other. Boulenger unites the *Iniomi* with the *Haplomi*, an arrangement which apparently has merit, for the most primitive and non-degenerate *Iniomi*, as *Aulopus* and *Synodus*, lack both mesocoracoid and orbitosphenoid. These bones are characteristic of the *Isospondyli*, but are wanting in *Haplomi*.

There is no adipose dorsal in the typical *Haplomi*, the dorsal is inserted far back, and the head is generally scaly. Most but not all of the species are of small size, living in fresh or brackish water, and they are found in almost all warm regions, though scantily represented in California, Japan, and Polynesia. The four families of typical *Haplomi* differ considerably from one another and are easily distinguished, although obviously related. Several other families are provisionally added to this group on account of agreement in technical characters, but their actual relationships are uncertain.

The Pikes.—The *Esocidæ* have the body long and slender and the mouth large, its bones armed with very strong, sharp teeth of different sizes, some of them being movable. The upper jaw is not projectile, and its margin, as in the *Salmonidæ*, is formed by the maxillary. The scales are small, and the dorsal fin far back and opposite the anal, and the stomach is without pyloric cæca. There is but a single genus, *Esox* (*Lucius* of Rafinesque), with about five or six living species. Four of these are North American, the other one being found in Europe, Asia, and North America.

All the pikes are greedy and voracious fishes, very destructive to other species which may happen to be their neighbors; "mere machines for the assimilation of other organisms." Thoreau describes the pike as "the swiftest, wariest, and most ravenous of fishes, which Josselyn calls the river-wolf. It is a solemn, stately, ruminant fish, lurking under the shadow of a lily-pad at noon, with still, circumspect, voracious eye; motionless as a jewel set in water, or moving slowly along to take up its position; darting from time to time at such unlucky fish

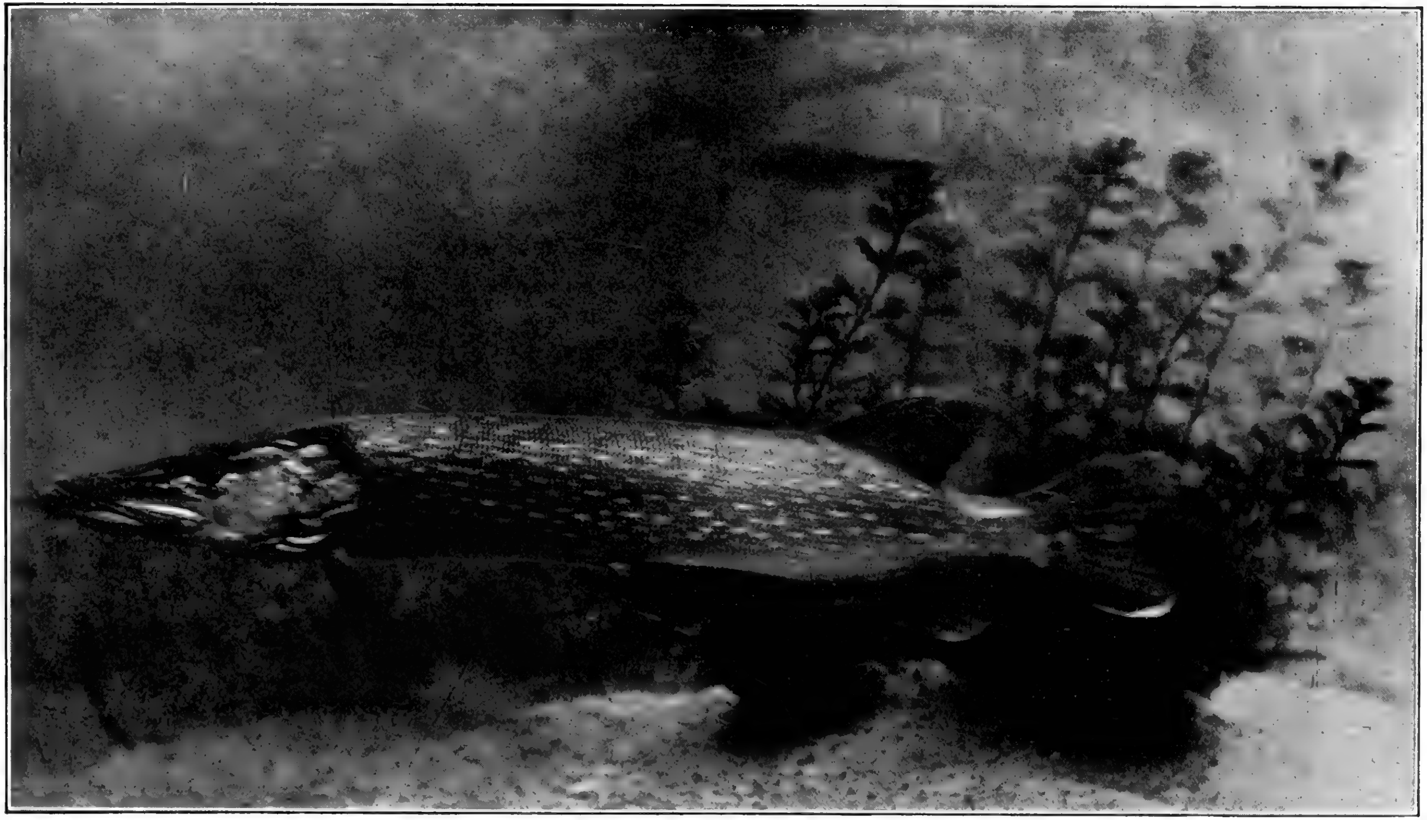


Fig. 150.—The Pike, *Esox-lucius* L. (From life by R. W. Shufeldt.)

or frog or insect as comes within its range, and swallowing it at one gulp. Sometimes a striped snake, bound for greener meadows across the stream, ends its undulatory progress in the same receptacle."

As food-fishes, all the *Esocidæ* rank high. Their flesh is white, fine-grained, disposed in flakes, and of excellent flavor.

The finest of the *Esocidæ*, a species to be compared, as a grand game fish, with the salmon, is the muskallunge (*Esox masquinongy*). Technically this species may be known by the fact that its cheeks and opercles are both naked on the lower half. It may be known also by its great size and by its

FIG. 151.—Muskallunge, *Esox masquinongy* Mitchill. Ecorse, Mich.

color, young and old being spotted with black on a golden-olive ground.

The muskallunge is found only in the Great Lake region, where it inhabits the deeper waters, except for a short time in the spring, when it enters the streams to spawn. It often reaches a length of six feet and a weight of sixty to eighty pounds. It is necessarily somewhat rare, for no small locality would furnish food for more than one such giant. It is, says Hallock, "a long, slim, strong, and swift fish, in every way formed for the life it leads, that of a dauntless marauder."

A second species of muskallunge, *Esox ohiensis*, unspotted but vaguely cross-barred, occurs sparingly in the Ohio River and the upper Mississippi Valley. It is especially abundant in Chautauqua Lake.*

The pike (*Esox lucius*) is smaller than the muskallunge, and is technically best distinguished by the fact that the opercles are naked below, while the cheeks are entirely scaly. The spots and cross-bars in the pike are whitish or yellowish, and always paler than the olive-gray ground color. It is the most

widely distributed of all fresh-water fishes, being found from the upper Mississippi Valley, the Great Lakes, and New England to Alaska and throughout northern Asia and Europe. It reaches a weight of ten to twenty pounds or more, being a large strong fish in its way, inferior only to the muskallunge. In England *Esox lucius* is known as the pike, while its young are called by the diminutive term pickerel. In America the name pickerel is usually given to the smaller species, and sometimes even to *Esox lucius* itself, the word being with us a synonym for pike, not a diminutive.

Of the small pike or pickerel we have three species in the eastern United States. They are greenish in color and banded or reticulated, rather than spotted, and, in all, the opercles as well as the cheeks are fully covered with scales. One of these (*Esox reticulatus*) is the common pickerel of the Eastern States, which reaches a respectable size and is excellent as food. The others, *Esox americanus* along the Atlantic seaboard and *Esox vermiculatus* in the middle West, seldom exceed a foot in length and are of no economic importance.

Numerous fossil species are found in the Tertiary of Europe, *Esox lepidotus* from the Miocene of Baden being one of the

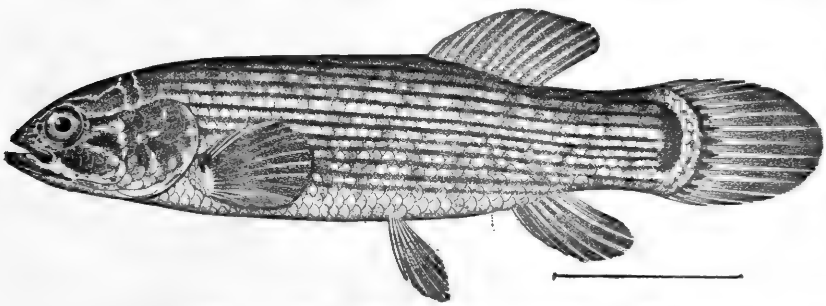


Fig. 152.—Mud-minnow, *Umbra pygmæa* (De Kay). New Jersey.

earliest and the best known; in this species the scales are much larger than in the recent species. The fossil remains would seem to indicate that the origin of the family was in southern Europe, although most of the living species are American.

The Mud-minnows.—Close to the pike is the family of *Umbridæ*, or mud-minnows, which technically differ from the pikes only in the short snout, small mouth, and weak dentition. The

mud-minnows are small, sluggish, carnivorous fishes living in the mud at the bottom of cold, clear streams and ponds. They are extremely tenacious of life, though soon suffocated in warm waters. The barred mud-minnow of the prairies of the middle West (*Umbra limi*) often remains in dried sloughs and bog-holes, and has been sometimes plowed up alive. *Umbra pygmæa*, a striped species, is found in the Eastern States and *Umbra crameri* in bogs and brooks along the Danube. This wide break in distribution seems to indicate a former wide extension of the range of *Umbridæ*, perhaps coextensive with *Esox*. Fossil *Umbridæ* are, however, not yet recognized.

The Killifishes.—Most of the recent *Haplomi* belong to the family of *Pœciliidæ* (killifishes, or Cyprinodonts). In this group the small mouth is extremely protractile, its margin formed by the premaxillaries alone much as in the spiny-rayed fishes. The teeth are small and of various forms according to the food. In most of the herbivorous forms they are incisor-like, serrate, and loosely inserted in the lips. In the species that eat insects or worms they are more firmly fixed. The head is scaly, the stomach without cæca, and the intestines are long in the plant-eating species and short in the others. There are nearly 200 species, very abundant from New England and California southward to Argentina, and in Asia and Africa also. In regions where rice is produced, they swarm in the rice swamps and ditches. Some of them enter the sea, but none of them go far from shore. Some are brilliantly colored, and in many species the males are quite unlike the females, being smaller and more showy. The largest species (*Fundulus*, *Anableps*) rarely reach the length of a foot, while *Heterandria formosa*, a diminutive inhabitant of the Florida rivers, scarcely reaches an inch. Some species are oviparous, but in most of the herbivorous forms, and some of the others, the eggs are hatched within the body, and the anal in the male is modified into a long sword-shaped intromittent organ, placed farther forward than the anal in the female. The young when born closely resemble the parent. Most of the insectivorous species swim at the surface, moving slowly with the eyes partly out of water. This habit in the genus *Anableps* (four-eyed fish, or *Cuatro ojos*) is associated with an

extraordinary structure of the eye. This organ is prominent and is divided by a horizontal partition into two parts, the upper, less convex, adopted for sight in the air, the lower in the water. The few species of *Anableps* are found in tropical America. The species of some genera swim near the bottom, but always in very shallow waters. All are very tenacious of life, and none have any commercial value although the flesh is good.

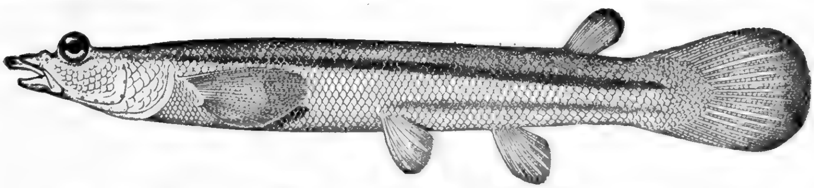


Fig. 152*a*.—Four-eyed Fish, *Anableps dovii* Gill. Tehuantepec, Mexico.

The unique structure of the eye of this curious fish has been carefully studied by Mr. M. C. Marsh, pathologist of the U. S. Fish Commission, who furnishes the following notes published by Evermann & Goldsborough:

"The eye is crossed by a bar, like the diameter of a circle, and parallel with the length of the body. This bar is darker than the other external portions of the eyeball and has its edges darker still. Dividing the external aspect of the eye equally, it has its lower edge on the same level as the back of the fish, which is flat and straight from snout to dorsal, or nearly the whole length of the fish; so that when the body of the fish is just submerged the level of the water reaches to this bar, and the lower half of the eye is in water, the upper half in the air. Upon dissecting the eyeball from the orbit, it appears nearly round. A membranous sheath covers the external part and invests most of the ball. It may be peeled off, when the dark bar on the external portion of the eye is seen to be upon this membrane, which may correspond to the conjunctiva. The back portion of the eyeball being cut off, one lens is found. The lining of the ball consists, in front, of one black layer, evidently choroid. Behind there is a retinal layer. The choroid layer turns up anteriorly, making a free edge comparable to an iris. The free edge is chiefly evident in the lower part of the eye. A large pupil is left, but is divided by two flaps, continuations of the choroid coat, projecting from either side and overlapping.

There are properly then two pupils, an upper and lower, separated by a band consisting of the two flaps, which may probably, by moving upward and downward, increase or diminish the size of either pupil; an upward motion of the flaps increasing the lower pupil at the expense of the other, and vice versa."

This division of the pupil into two parts permits the fish, when swimming at the surface of the water, as is its usual custom, to see in the air with the upper portion and in the water with the lower. It is thus able to see not only such insects as are upon the surface of the water or flying in the air above, but also any that may be swimming beneath the surface.

According to Mr. E. W. Nelson, "the individuals of this species swim always at the surface and in little schools arranged in platoons or abreast. They always swim headed upstream against the current, and feed upon floating matter which the current brings them. A platoon may be seen in regular for-

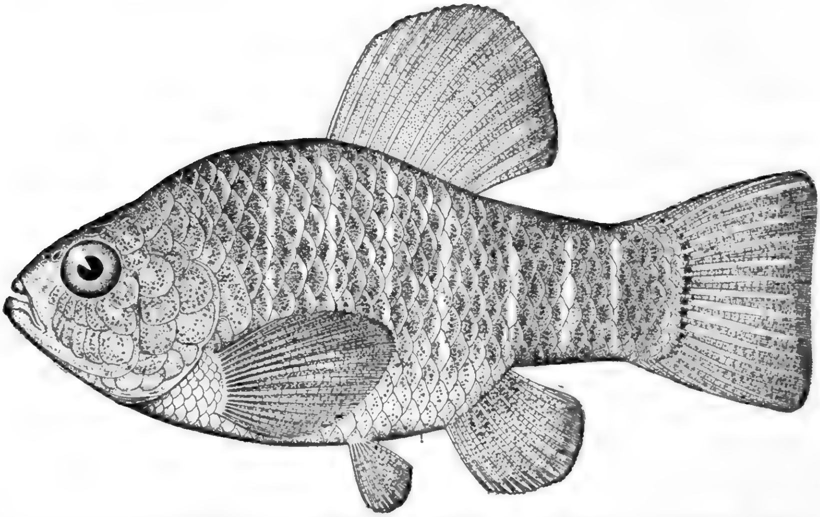


Fig. 153.—Round Minnow, *Cyprinodon variegatus* Lacépède. St. George Island, Maryland.

mation breasting the current, either making slight headway upstream or merely maintaining their station, and on the qui vive for any suitable food the current may bring. Now and then one may be seen to dart forward, seize a floating food particle, and then resume its place in the platoon. And thus

they may be observed feeding for long periods. They are almost invariably found in running water well out in the stream, or at least where the current is strongest and where floating matter is most abundant, for it is upon floating matter that they seem chiefly to depend. They are not known to jump out of the water to catch insects flying in the air or resting upon vegetation above the water surface, nor do they seem to feed to any extent upon all small crustaceans or other portions of the plankton beneath the surface.

"When alarmed—and they are wary and very easily frightened—they escape by skipping or jumping over the water,

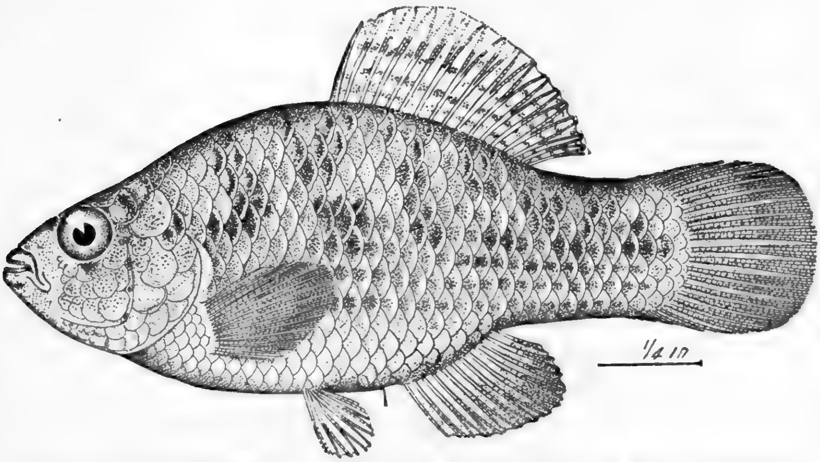


FIG. 154.—Everglade Minnow, *Jordanella floridæ* Goode & Bean. Everglades of Florida.

2 or 3 feet at a skip. They rise entirely out of the water, and at a considerable angle, the head pointing upward. In descending the tail strikes the water first and apparently by a sculling motion new impetus is acquired for another leap. This skipping may continue until the school is widely scattered. When a school has become scattered, and after the cause of their fright has disappeared, the individuals soon rejoin each other. First two will join each other and one by one the others will join them until the whole school is together again. Rarely do they attempt to dive or get beneath the surface; when they do they have great difficulty in keeping under and soon come to the surface again."

Of the many genera of *Pœciliidæ*, top-minnows, and killi-fishes we may mention the following: *Cyprinodon* is made

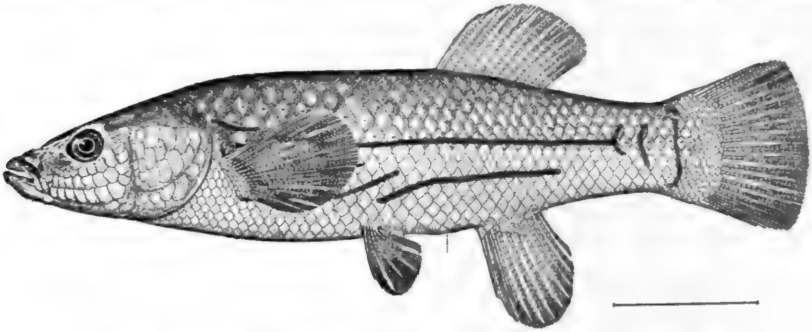


FIG. 155.—Mayfish, *Fundulus majalis* (L.) (male). Wood's Hole.

up of chubby little fishes of eastern America with tricuspid, incisor teeth, oviparous and omnivorous. Very similar to

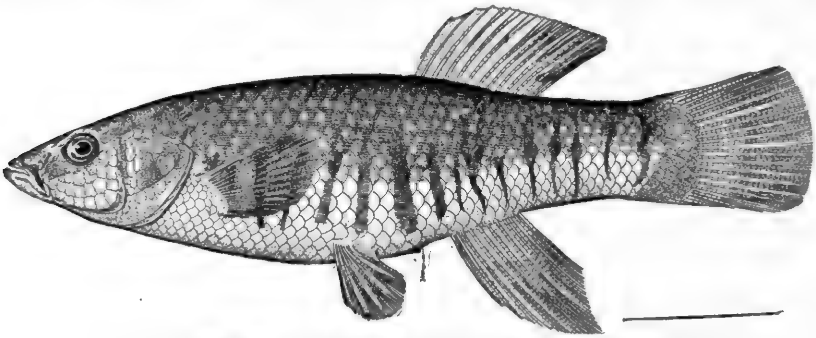


FIG. 156.—Mayfish, *Fundulus majalis* (female). Wood's Hole.

these but smaller are the species of *Lebias* in southern Europe. *Jordanella floridæ* of the Florida everglades is similar, but with

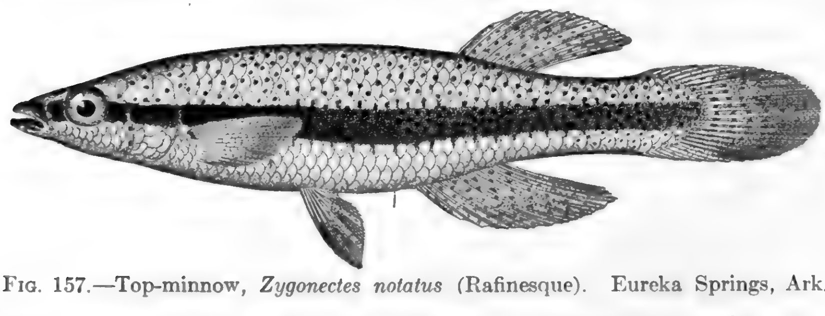


FIG. 157.—Top-minnow, *Zygonectes notatus* (Rafinesque). Eureka Springs, Ark.

the dorsal fin long and its first ray enlarged and spine-like. It strongly resembles a young sunfish. Most of the larger forms

belong to *Fundulus*, a genus widely distributed from Maine to Guatemala and north to Kansas and southern California. *Fundulus majalis*, the Mayfish of the Atlantic Coast, is the largest of the genus. *Fundulus heteroclitus*, the killifish, the most abundant. *Fundulus diaphanus* inhabits sea and lake

FIG. 158.—Death Valley Fish, *Empetrichthys merriami* Gilbert. Amargosa Desert, Cal. Family *Pœciliidæ*. (After Gilbert.)

indiscriminately. *Fundulus stellifer* of the Alabama is beautifully colored, as is *Fundulus zebrinus* of the Rio Grande. The genus *Zygonectes* includes dwarf species similar to *Fundulus*, and *Adinia* includes those with short, deep body. *Goodea atripinnis* with tricuspid teeth lives in warm springs in Mexico,

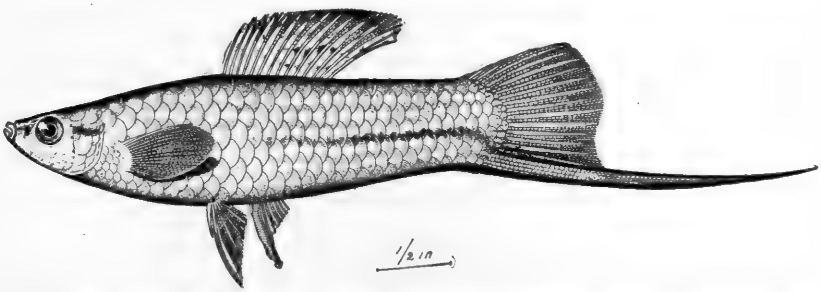


FIG. 159.—Sword-tail Minnow, male, *Xiphophorus helleri* Heckel. The anal fin modified as an intromittent organ. Vera Cruz.

and several species of *Goodea*, *Gambusia*, *Pœcilia*, and other genera inhabit hot springs of Mexico, Central America, and Africa. The genus *Gambusia*, the top-minnows, includes numerous species with dwarf males having the anal modified. *Gambusia affinis* abounds in all kinds of sluggish water in

FIG. 160.—*Goodea luitpoldi* (Steindachner). A viviparous fish from Lake Patzcuaro, Mexico. Family *Pœciliidæ*. (After Meek.)

the southern lowlands, gutters and even sewers included. It brings forth its brood in early spring. Viviparous and herbivorous with modified anal are the species of *Pœcilia*, abundant throughout Mexico and southward to Brazil; *Mollienesia* very similar, with a banner-like dorsal fin, showily marked, occurs from Louisiana southward, and *Xiphophorus*, with a sword-shaped lobe on the caudal, abounds in Mexico; *Characodon* and *Goodea* (see Fig. 53, Vol. I) in Mexico have notched teeth, and finally, *Heterandria* contains some of the least of fishes, the handsomely colored males barely half an inch long.

In Lake Titicaca in the high Andes is a peculiar genus (*Orestias*) without ventral fins. Still more peculiar is *Empetrichthys merriami* of the desert springs of the hot and rainless Death Valley in California, similar to *Orestias*, but with enormously enlarged pharyngeals and pharyngeal teeth, an adaptation to some unknown purpose. Fossil Cyprinodonts are not rare from the Miocene in southern Europe. The numerous species are allied to *Lebias* and *Cyprinodon*, and are referred to *Prolebias* and *Pachylebias*. None are American, although two American extinct genera, *Gephyrura* and *Proballostomus*, are probably allied to this group.

Amblyopsidæ.—The cave-fishes, *Amblyopsidæ*, are the most remarkable of the haplomous fishes. In this family the vent is

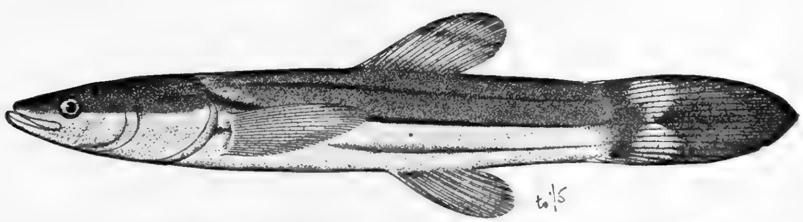


FIG. 161.—Dismal Swamp Fish, *Chologaster cornutus* Agassiz. Supposed ancestor of *Typhlichthys*. Virginia.

placed at the throat. The form is that of the *Pœciliidæ*, but the mouth is larger and not protractile. The species are viviparous, the young being born at about the length of a quarter of an inch.

In the primitive genus *Chologaster*, the fish of the Dismal Swamp, the eyes are small but normally developed. *Chologaster cornutus* abounds in the black waters of the Dismal Swamp

of Virginia, thence southward through swamps and rice-fields to Okefinokee Swamp in northern Florida. It is a small fish, less than two inches long, striped with black, and with the habit of a top-minnow. Other species of *Chologaster*, possessing eyes and color, but provided also with tactile papillæ, are found in cave springs in Tennessee and southern Illinois.

From *Chologaster* is directly descended the small blindfish *Typhlichthys subterraneus* of the caves of the Subcarboniferous limestone rocks of southern Indiana and southward to northern Alabama. As in *Chologaster*, the ventral fins are wanting. The eyes, present in the young, become defective and useless in the adult, when they are almost hidden by other tissues. The different parts of the eye are all more or less incomplete, being without function. The structure of the eye has been described in much detail in several papers by Dr. Carl H. Eigen-

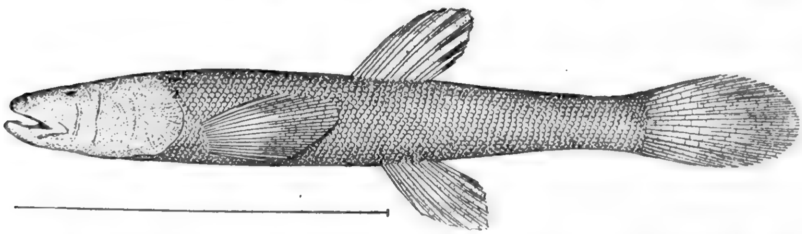


FIG. 162.—Blind Cave-fish, *Typhlichthys subterraneus* Girard. Mammoth Cave, Kentucky.

mann. As to the cause of the loss of eyesight two chief theories exist—the Lamarckian theory of the inheritance in the species of the results of disuse in the individual and the Weissmannian doctrine that the loss of sight is a result of panmixia or cessation of selection. This may be extended to cover reversal of selection, as in the depths of the great caves the fish without eyes would be at some slight advantage. Dr. Eigenmann inclines to the Lamarckian doctrine, but the evidence brought forward fails to convince the present writer that results of individual use or disuse ever become hereditary or that they are ever incorporated in the characters of a species. In the caves of southern Missouri is an independent case of similar degradation. *Troglichthys rosæ*, the blindfish of this region, has the eye in a different phase of degeneration. It is thought to be separately descended from

some other species of *Chologaster*. Of this species Mr. Garman and Mr. Eigenmann have given detailed accounts from somewhat different points of view.

Concerning the habits of the blindfish (*Troglichthys rosæ*), Mr. Garman quotes the following from notes of Miss Ruth Hoppin, of Jasper County, Missouri: "For about two weeks I have been watching a fish taken from a well. I gave him considerable water, changed once a day, and kept him in an uninhabitated place subject to as few changes of temperature as possible. He seems perfectly healthy and as lively as when first taken from the well. If not capable of long fasts, he must live on small organisms my eye cannot discern. He is hardly ever still, but moves about the sides of the vessel constantly, down and up, as if needing the air. He never swims through

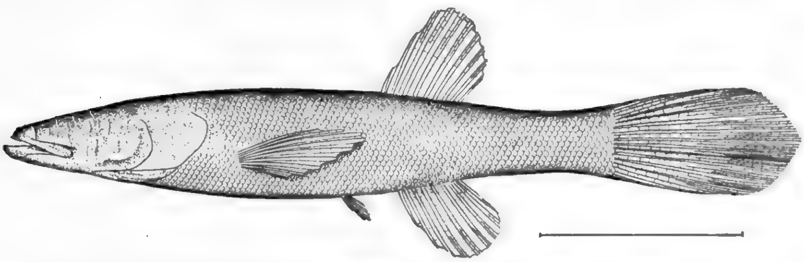


FIG. 163.—Blindfish of the Mammoth Cave, *Amblyopsis spelæus* (De Kay). Mammoth Cave, Kentucky.

the body of the water away from the sides unless disturbed. Passing the finger over the sides of the vessel under water I find it slippery. I am careful not to disturb this slimy coating when the water is changed. . . . Numerous tests convince me that it is through the sense of touch, and not through hearing, that the fish is disturbed; I may scream or strike metal bodies together over him as near as possible, yet he seems to take no notice whatever. If I strike the vessel so that the water is set in motion, he darts away from that side through the mass of water, instead of around in his usual way. If I stir the water or touch the fish, no matter how lightly, his actions are the same."

The more famous blindfish of the Mammoth Cave, *Amblyopsis spelæus*, reaches a length of five inches. It possesses ventral fins. From this fact we may infer its descent from

some extinct genus which, unlike *Chologaster*, retains these fins. The translucent body, as in the other blindfishes, is covered with very delicate tactile papillæ, which form a very delicate organ of touch.

The anomalous position of the vent in *Amblyopsidæ* occurs again in an equally singular fish, *Aphredoderus sayanus*, which is found in the same waters throughout the same region in which *Chologaster* occurs. It would seem as if these lowland fishes of the southern swamps were remains of a once much more extensive fauna.

No fossil allies of *Chologaster* are known.

Kneriidæ, etc.—The members of the order of *Haplomi*, recorded above, differ widely among themselves in various details of osteology. There are other families, probably belonging here, which are still more aberrant. Among these are the *Kneriidæ*, and perhaps the entire series of forms called *Iniomi*, most of which possess the osteological traits of the *Haplomi*.

The family of *Kneriidæ* includes a few very small fishes of the rivers of Africa.

The Galaxiidæ.—The *Galaxiidæ* are trout-like fishes of the southern rivers, where they take the place of the trout of the northern zones. The species lack the adipose fins and have the dorsal inserted well backward. According to Boulenger these fishes, having no mesocoraoid, should be placed among the *Haplomi*. Yet their relation to the *Haplochitonidæ* is very close and both families may really belong to the *Isospondyli*. *Galaxias truttaceus* is the kokopu, or "trout," of New Zealand. *Galaxias ocellatus* is the yarra trout of Australia. Several other species are found in southern Australia, Tasmania, Patagonia, and the Falkland Islands, and even in South Africa. This very wide distribution in the rivers remote from each other has given rise to the suggestion of a former land connection between Australia and Patagonia. Other similar facts have led some geologists to believe in the existence of a former great continent called Antarctica, now submerged except that part which constitutes the present unknown land of the Antarctic.

As intimated on p. 253, Vol. I, this distribution of *Galaxias* with similar anomalies in other groups could not if unsupported by geological evidence be held to prove the former extension

of the Antarctic continent. Dr. Boulenger * has recently shown that *Galaxias* lives freely in salt water, a fact sufficient

* Dr. Boulenger (*Nature*, Nov. 27, 1902) has the following note on *Galaxias:* "Most text-books and papers discussing geographical distribution have made much of the range of a genus of small fishes, somewhat resembling trout, the *Galaxias*, commonly described as true fresh-water forms, which have long been known from the extreme south of South America, New Zealand, Tasmania, and southern Australia. The discovery, within the last few years, of a species of the same genus in fresh water near Cape Town, whence it had previously been described as a loach by F. de Castelnau, has added to the interest, and has been adduced as a further argument in support of the former existence of an Antarctic continent. In alluding to this discovery when discussing the distribution of African fresh-water fishes in the introduction to my work 'Les Poissons du Bassin du Congo,' in 1901, I observed that, contrary to the prevailing notion, all species of *Galaxias* are not confined to fresh water, and that the fact of some living both in the sea and in rivers suffices to explain the curious distribution of the genus; pointing out that in all probability these fishes were formerly more widely distributed in the seas south of the tropic of Capricorn, and that certain species, adapting themselves entirely to fresh-water life, have become localized at the distant points where they are now known to exist. Although as recently as October last the distinguished American ichthyologist D. S. Jordan wrote (*Science*, xiv, p. 20): 'We know nothing of the power of *Galaxias* to survive submergence in salt water, if carried in a marine current'; it is an established fact, ascertained some years ago by F. E. Clarke in New Zealand and by R. Vallentin in the Falkland Islands, that *Galaxias attenuatus* lives also in the sea. In New Zealand it periodically descends to the sea, where it spawns, from January to March, and returns from March to May. In accordance with these marine habits, this species has a much wider range than any of the others, being known from Chile, Patagonia, Tierra del Fuego, the Falkland Islands, New Zealand, Tasmania, and southern Australia.

"I now wish to draw attention to a communication made by Captain F. W. Hutton in the last number of the Transactions of the New Zealand Institute (xxxiv, p. 198), 'On a Marine Galaxias from the Auckland Islands.' This fish, named *Galaxias bollansi*, was taken out of the mouth of a specimen of *Merganser australis* during the collection excursion to the southern islands of New Zealand made in January, 1901, by His Excellency the Earl of Ranfurly.

"It is hoped that by giving greater publicity to these discoveries the family *Galaxidæ* will no longer be included among those strictly confined to fresh waters, and that students of the geographical distribution of animals will be furnished with a clue to a problem that has so often been discussed on insufficient data. As observed by Jordan (*l. c.*), 'all anomalies in distribution cease to be such when the facts necessary to understand them are at hand.'

"Of the fresh-water species of *Galaxias*, eight are known from New Zealand and the neighboring islands, seven from New South Wales, three or four from south Australia, one from west Australia, two from Tasmania, seven from South America, from Chile southwards, and one from the Cape of Good Hope."

to account for its wide distribution in the rivers of the southern hemisphere.

Neochanna is an ally of *Galaxias* living in burrows in the clay or mud like a crayfish, often at a distance from water. As in various other mud-living types, the ventral fins are obsolete.

Order Xenomi.—We must place near the *Haplomi* the singular group of *Xenomi* (ξενός, strange; ὦμος, shoulder), regarded by Dr. Gill as a distinct order. Externally these fish much resemble the mud-minnows, differing mainly in the very broad pectorals. But the skeleton is thin and papery, the two coracoids forming a single cartilaginous plate imperfectly divided. The pectorals are attached directly to this without the intervention of actinosts, but in the distal third, according to Dr. Charles H. Gilbert, the coracoid plate begins to break up

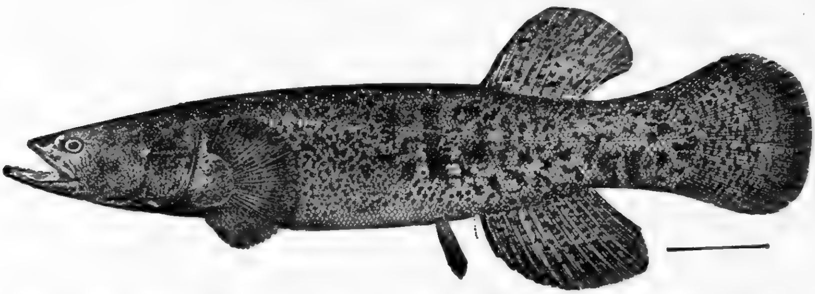


FIG. 164.—Alaska Blackfish, *Dallia pectoralis* (Bean). St. Michaels, Alaska.

into a fringe of narrow cartilaginous strips. These about equal the very large number (33 to 36) of pectoral rays, the basal part of each ray being slightly forked to receive the tip of the cartilaginous strip.

"In the deep-sea eels of the order *Heteromi* there is a somewhat similar condition of the coracoid elements inasmuch as the hypercoracoid and hypocoracoid though present are merely membranous elements surrounded by cartilage and the actinosts are greatly reduced. It seems probable that we are dealing in the two cases with independent degeneration of the shoulder-girdle and that the two groups (*Xenomi* and *Heteromi*) are not really related." (Gilbert.)

Of the single family *Dalliidæ*, one species is known, the Alaska blackfish, *Dallia pectoralis*.

This animal, formed like a mud-minnow, reaches a length of eight inches and swarms in the bogs and sphagnum swamps of northwestern Alaska and westward through Siberia. It is found in countless numbers according to its discoverer, Mr. L. M. Turner, "wherever there is water enough to wet the skin of a fish," and wherever it occurs it forms the chief food of the natives. Its vitality is most extraordinary. Blackfishes will remain frozen in baskets for weeks and when thawed out are as lively as ever. Turner gives an account of a frozen individual swallowed by a dog which escaped in safety after being thawed out by the heat of the dog's stomach.

CHAPTER XI

ACANTHOPTERYGII; SYNENTOGNATHI

ORDER **Acanthopterygii, the Spiny-rayed Fishes.** — The most of the remaining bony fishes constitute a natural group for which the name *Acanthopterygii* (ἄκανθα, spine; *πτέρυξ*, *πτερόν*, fin or wing) may be used. This name is often written *Actinopteri*, a form equally correct and more euphonious and convenient. These fishes are characterized, with numerous exceptions, by the presence of fin spines, by the connection of the ventral fins with the shoulder-girdle, by the presence in general of more than one spine in the anterior part of dorsal and anal fins, and as a rule of one spine and five rays in the ventral fins, and by the absence in the adult of a duct to the air-bladder. Minor characters are these: the pectoral fins are inserted high on the shoulder-girdle, the scales are often ctenoid, and the edge of the upper jaw is formed by the premaxillary alone, the maxillary being always toothless.

But it is impossible to define or limit the group by any single character or group of characters. It is connected with the *Malacopterygii* through the *Haplomi* on the one hand by transitional groups of genera which may lack any one of these characters. On the other hand, in the extreme forms, each of these distinctive characters may be lost through degeneration. Thus fin spines, ctenoid scales, and the homocercal tail are lost in the codfishes, the connection of ventrals with shoulder-girdle fails in the *Percesoces*, etc., and the development of the air-duct is subject to all sorts of variations. In one family even the adipose fin remains through all the changes and modifications the species have undergone.

The various transitional forms between the *Haplomi* and the perch-like fishes have been from time to time regarded as

separate orders. Some of them are more related to the perch, others rather to ancestors of salmon or pike, while still others are degenerate offshoots, far enough from either.

On the whole, all these forms, medium, extreme and transitional, may well be placed in one order, which would include the primitive flying-fishes and mullets, the degraded globefishes, and the specialized flounders. As for the most part these are spiny-rayed fishes, Cuvier's name *Acanthopterygii*, or *Acanthopteri*, will serve us as well as any. The *Physoclysti* of Müller, the *Thoracices* of older authors, and the *Ctenoidei* of Agassiz include substantially the same series of forms. The order *Teleocephali* of Gill (τελεός, perfect; κεφαλή, head) has been lately so restricted as to cover nearly the same ground. In Gill's most recent catalogue of families, the order *Teleocephali* includes the *Haplomi* and rejects the *Hemibranchii*, *Lophobranchii*, *Plectognathi*, and *Pediculati*, all of these being groups characterized by sharply defined but comparatively recent characters not of the highest importance. As originally arranged, the order *Teleocephali* included the soft-rayed fishes as well. From it the *Ostariophysi* were first detached, and still later the *Isospondyli* were regarded by Dr. Gill as a separate order.

We may first take up serially as suborders the principal groups which serve to effect the transition from soft-rayed to spiny-rayed fishes.

Suborder Synentognathi. — Among the transitional forms between the soft-rayed and the spiny-rayed fishes, one of the most important groups is that known as *Synentognathi* (σύν, together; ἔν, within; γνάθος, jaw). These have, in brief, the fins and shoulder-girdle of *Haplomi*, the ventral fins abdominal, the dorsal and anal without spines. At the same time, as in the spiny-rayed fishes, the air-bladder is without duct and the pectoral fins are inserted high on the side of the body. With these traits are two others which characterize the group as a suborder. The lower pharyngeal bones are solidly united into one bone and the lateral line forms a raised ridge along the lower side of the body. These forms are structurally allied to the pikes (*Haplomi*), on the one hand, and to the mullets (*Percesoces*), on the other, and this relationship accords with their general appearance. In this group as in all the remain-

ing families of fishes, there is no mesocoracoid, and in very nearly all of these families the duct to the air-bladder disappears at an early stage of development.

The Garfishes: Belonidæ. — There are two principal groups or families among the *Synentognathi*, the *Belonidæ*, with strong jaws and teeth, and the *Exocœtidæ*, in which these structures are feeble. Much more important characters appear in the anatomy. In the *Belonidæ* the third upper pharyngeal is small, with few teeth, and the maxillary is firmly soldered to the premaxillary. The vertebræ are provided with zygapophyses. The species of *Belonidæ* are known as garfishes, or needle-fishes. They resemble the garpike in form, but have nothing else in common. The body is long and slender, covered with small scales. Sharp, unequal teeth fill the long jaws and the

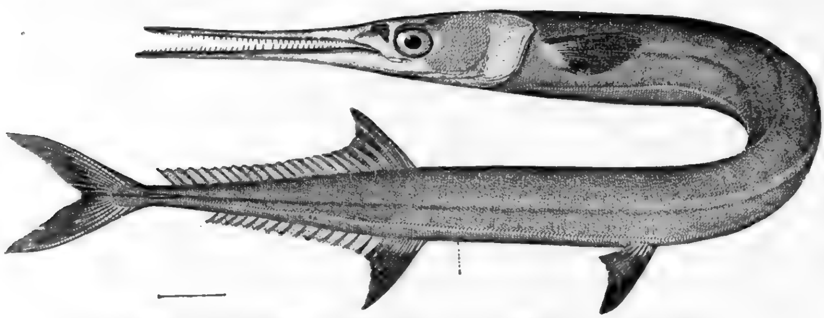


FIG. 165.—Needle-fish, *Tylosurus acus* (Lacépède). New York.

dorsal is opposite the anal, on the hinder part of the body. These fishes are green in color, even the bones being often bright green, while the scales on the sides have a silvery luster. The species are excellent as food, the green color being associated with nothing deleterious. All are very voracious and some of the larger species, 5 or 6 feet long, may be dangerous even to man. Fishermen have been wounded or killed by the thrust of the sharp snout of a fish springing into the air. The garfishes swim near the surface of the water and often move with great swiftness, frequently leaping from the water. The genus *Belone* is characterized by the presence of gill-rakers. *Belone belone* is a small garfish common in southern Europe. *Belone platura* occurs in Polynesia. The American species (*Tylosurus*) lack gill-rakers. *Tylosurus marinus*, the common garfish of

the eastern United States, often ascends the rivers. *Tylosurus raphidoma*, *Tylosurus fodiator*, *Tylosurus acus*, and other species are very robust, with short strong jaws. *Athlennes hians* is a very large fish with the body strongly compressed, almost ribbon-like. It is found in the West Indies and across the Isthmus as far as Hawaii. Many other species, mostly belonging to *Tylosurus*, abound in the warm seas of all regions. *Tylosurus ferox* is the long tom of the Australian markets. *Potamorrhaphis* with the dorsal fin low is found in Brazilian rivers. A few fossil species are referred to *Belone*, *Belone flava* from the lower Eocene being the earliest.

The Flying-fishes: Exocœtidæ.—The family of *Exocœtidæ* includes the flying-fishes and several related forms more or less intermediate between these and the garfishes. In these fishes the teeth are small and nearly equal and the maxillary is separate from the premaxillary. The third upper pharyngeal is much enlarged and there are no zygapophyses to the vertebræ.

The skippers (*Scombresox*) have slender bodies, pointed jaws, and, like the mackerel, a number of detached finlets behind dorsal and anal, although in other respects they show no affinity to the mackerel. The common skipper, or saury (*Scombresox saurus*), is found on both shores of the North Atlantic swimming in large schools at the surface of the water, frequently leaping for a little distance like the flying-fish. They are pursued by the mackerel-like fishes, as the tunny or bonito, and sometimes by porpoises. According to Mr. Couch, the skippers, when pursued, "mount to the surface in multitudes and crowd on each other as they press forward. When still more closely pursued, they spring to the height of several feet, leap over each other in singular confusion, and again sink beneath. Still further urged, they mount again and rush along the surface, by repeated starts, for more than one hundred feet, without once dipping beneath or scarcely seeming to touch the water. At last the pursuer springs after them, usually across their course, and again they all disappear together. Amidst such multitudes—for more than twenty thousand have been judged to be out of the water together—some must fall a prey to the enemy; but so many hunting in company, it must be long before the pursuers abandon. From inspection we could scarcely judge

the fish to be capable of such flights, for the fins, though numerous, are small, and the pectoral far from large, though the angle of their articulation is well adapted to raise the fish by the direction of their motions to the surface."

A similar species, *Cololabis saira*, with the snout very much shorter than in the Atlantic skipper, is the *Samma* of the fishermen of Japan.

The hard-head (*Chriodorus atherinoides*) has no beak at all and its tricuspid incisor teeth are fitted to feed on plants. In this genus, as in the flying-fishes, there are no finlets. The hard-head is an excellent food-fish abundant about the Florida Keys but not yet seen elsewhere.

Another group between the gars and the flying-fishes is that of the halfbeaks, or balaos, *Hemirhamphus*, etc. These are also

FIG. 166.—Saury, *Scombresox saurus* (L.). Wood's Hole.

vegetable feeders, but with much smaller teeth, and the lower jaw with a spear-like prolongation to which a bright-red membrane is usually attached. Of the halfbeaks there are several genera, all of the species swimming near the surface in schools and sometimes very swiftly. Some of them leap into the air and sail for a short distance like flying-fishes, with which group the halfbeaks are connected by easy gradations. The com-

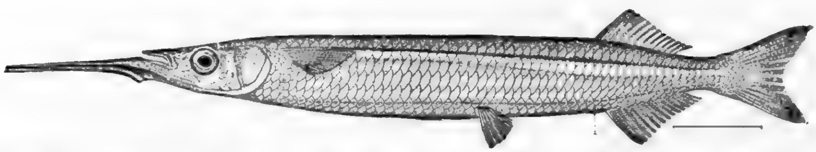


FIG. 167.—Halfbeak, *Hyporhamphus unifasciatus* (Ranzani). Chesapeake Bay.

monest species along our Atlantic coast is *Hyporhamphus unifasciatus;* a larger species, *Hemirhamphus brasiliensis*, abounds about the Florida Keys. *Euleptorhamphus longirostris*, a ribbon-shaped elongate fish, with long jaw and long pectorals, is taken in the open sea, both in the Altantic and Pacific, being common in Hawaii. The Asiatic genus *Zenarchopterus* is viviparous,

having the anal fin much modified in the male, forming an intromittent organ, as in the *Pœciliidæ*. One species occurs in the river mouths in Samoa.

The flying-fishes have both jaws short, and at least the

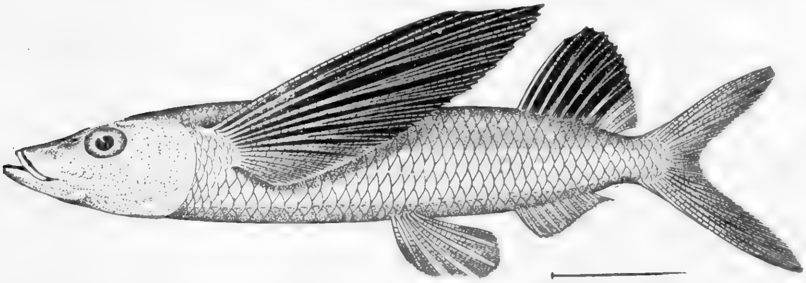


FIG. 168.—Sharp-nosed Flying-fish, *Fodiator acutus* (Val.). Panama.

pectoral fins much enlarged, so that the fish may sail in the air for a longer or shorter distance.

The smaller species have usually shorter fins and approach more nearly to the halfbeaks. *Fodiator acutus*, with sharp jaws, and *Hemiexocœtus*, with a short beak on the lower jaw, are especially intermediate. The flight of the flying-fishes is described in detail on p. 157, Vol. I.

The Catalina flying-fish, *Cypselurus californicus*, of the shore of southern California is perhaps the largest of the known species, reaching a length of 18 inches. To this genus, *Cypselurus*, having a long dorsal and short anal, and with ventrals enlarged as well as pectorals, belong all the species strongest in flight, *Cypselurus heterurus* and *furcatus* of the Atlantic, *Cypselurus simus* of Hawaii and *Cypselurus agoo* in Japan. The very young of most of these species have a long barbel at the chin which is lost with age.

In the genus *Exonautes* the base of anal fin is long, as long as that of the dorsal. The species of this group, also strong in flight, are widely distributed. Most of the European flying-fishes, as *Exonautes rondeleti*, *Exonautes speculiger*, and *Exonautes vinciguerræ*, belong to this group, while those of *Cypselurus* mostly inhabit the Pacific. The large Australian species *Exonautes unicolor*, Fig. 226, Vol. I, belongs to this group. In the restricted genus *Exocœtus* the ventral fins are short and not used in flight. *Exocœtus volitans* (*evolans*) is a small flying-fish,

with short ventral fins not used for flight. It is perhaps the most widely distributed of all, ranging through almost all warm seas. *Parexocœtus brachypterus*, still smaller, and with shorter, grasshopper-like wings, is also very widely distributed. An excellent account of the flying-fishes of the world has been given by Dr. C. F. Lütken (1876), the University of Copenhagen,

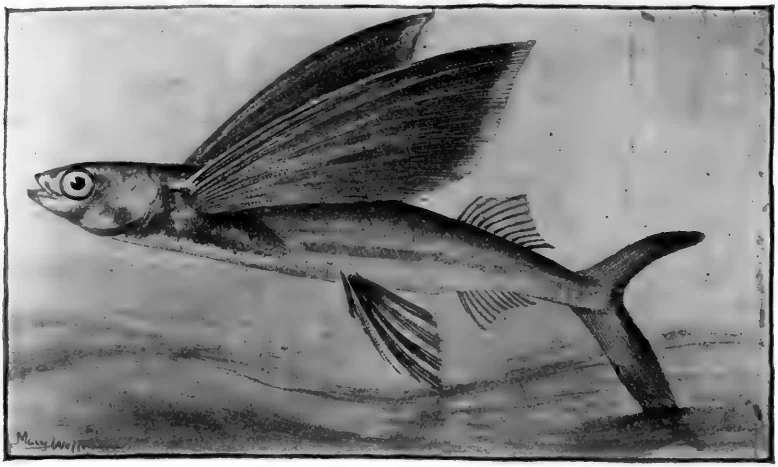


FIG. 169.—Catalina Flying-fish, *Cypselurus californicus* (Cooper). Santa Barbara.

which institution has received a remarkably fine series from trading-ships returning to that port. Later accounts have been given by Jordan and Meek, and by Jordan and Evermann.

Very few fossil *Exocœtidæ* are found. Species of *Scombresox* and *Hemirhamphus* are found in the Tertiary, the earliest being *Hemirhamphus edwardsi* from the Eocene of Monte Bolca. No fossil flying-fishes are known, and the genera, *Exocœtus*, *Exonautes*, and *Cypselurus* are doubtless all of very recent origin.

CHAPTER XII

PERCESOCES AND RHEGNOPTERI

SUBORDER Percesoces.—In the line of direct ascending transition from the *Haplomi* and *Synentognathi*, the pike and flying-fish, towards the typical perch-like forms, we find a number of families, perch-like in essential regards but having the ventral fins abdominal.

These types, represented by the mullet, the silverside, and the barracuda, have been segregated by Cope as an order called *Percesoces* (Perca, perch; Esox, pike), a name which correctly describes their real affinities. In these typical forms, mullet, silverside, and barracuda, the affinities are plain, but in other transitional forms, as the threadfin and the stickleback, the relationships are less clear. Cope adds to the series of *Percesoces* the *Ophiocephalidæ*, which Gill leaves with the *Anabantidæ* among the spiny-rayed forms. Boulenger adds also the sand-lances (*Ammodytidæ*) and the threadfins (*Polynemidæ*), while Woodward places here the *Crossognathidæ*. In the present work we define the *Percesoces* so as to include all spiny-rayed fishes in which the ventral fins are naturally abdominal, excepting those having a reduced number of gill-bones, or of actinosts, or other peculiarities of the shoulder-girdle. The *Ammodytidæ* have no real affinities with the *Percesoces*. The *Crossognathidæ* and other families with abdominal ventrals and the dorsal spines wholly obsolete may belong with the *Haplomi*. Boulenger places the *Chiasmodontidæ*, the *Stromateidæ*, and the *Tetragonuridæ* among the *Percesoces*, an arrangement of very doubtful validity. In most of the *Percesoces* the scales are cycloid, the spinous dorsal forms a short separate fin, and in all the air-duct is wanting.

The Silversides: Atherinidæ.—The most primitive of living *Percesoces* constitute the large family of silversides (*Atherinidæ*),

known as "fishes of the King," Pescados del Rey, Pesce Rey, or Peixe Re, wherever the Spanish or Portuguese languages are spoken. The species are, in general, small and slender fishes of dry and delicate flesh, feeding on small animals. The mouth is small, with feeble teeth. There is no lateral line, the color is translucent green, with usually a broad lateral band of silver. Sometimes this is wanting, and sometimes it is replaced by burnished black. Some of the species live in lakes or rivers, others in bays or arms of the sea, but never at a distance from the shore or in water of more than a few feet in depth. The larger species are much valued as food, the smaller ones, equally delicate, are fried in numbers as "whitebait," but the bones are firmer and more troublesome than in the smelts and young herring. The species of the genus *Atherina*, known as "friars," or "brit," are chiefly European, although some occur in almost all warm or temperate seas. These are small fishes, with the mouth relatively large and oblique and the scales rather large and firm. *Atherina hepsetus* and *A. presbyter* are common in Europe, *Atherina stipes* in the West Indies, *Atherina bleekeri* in Japan, and *Atherina insularum* and *A. lacunosa* in Polynesia. The genus *Chirostoma* contains larger species, with projecting lower jaw, abounding in the lakes of Mexico. *Chirostoma humboldtianum* is very abundant about Mexico City. Like all the other species of this genus it is remarkably excellent as food, the different species constituting the famous "Pescados Blancos" of the great lakes of Chapala and Patzcuaro of the western slope of Mexico. A very unusual circumstance is this: that numerous very closely related species occupy the same waters and are taken in the same nets. In zoology, generally, it is an almost universal rule that very closely related species occupy different geographical areas, their separation being due to barriers which prevent interbreeding. But in the lake of Chapala, near Guadalajara, Prof. John O. Snyder and the present writer, and subsequently Dr. S. E. Meek, found ten distinct species of *Chirostoma*, all living together, taken in the same nets and scarcely distinguishable except on careful examination. Most of these species are very abundant throughout the lake, and all reach a length of twelve to fifteen inches. These species are *Chirostoma estor*, *Ch. lucius*, *Ch. sphyræna*,

Ch. ocotlane, *Ch. lermæ*, *Ch. chapalæ*, *Ch. grandocule*, *Ch. labarcæ*, *Ch. promelas*, and *Ch. bartoni*. A similar assemblage of species

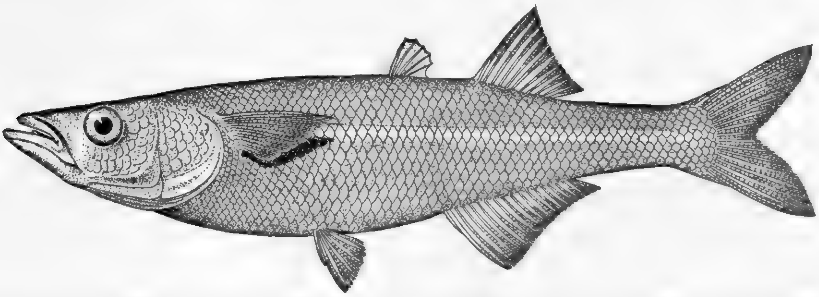


Fig. 170.—Pescado blanco, *Chirostoma humboldtianum* (Val.). Lake Chalco, City of Mexico.

nearly all different from these was obtained by Dr. Seth E. Meek in the lake of Patzcuaro, farther south. In this lake were found *Ch. attenuatum*, *Ch. patzcuaro*, *Ch. humboldtianum*, *Ch. grandocule*, and *Ch. estor*. The lake of Zirahuen, near Chapala, contains *Ch. estor* and *Ch. zirahuen*.

Still another species, *Ch. jordani*, is found about the city of Mexico, where it is sold baked in corn-husks. Along the coasts of Peru, Chile, and Argentina is found still another assemblage of fishes of the king, with very small scales, constituting the genera *Basilichthys* and *Gastropterus* (*Pisciregia*). *Basilichthys microlepidotus* is the common Pesca del Rey of Chile. The small silversides, or "brit," of our Atlantic coast belong to numerous species of *Menidia*, *Menidia notata* to the northward and *Menidia menidia* to the southward being most abundant.

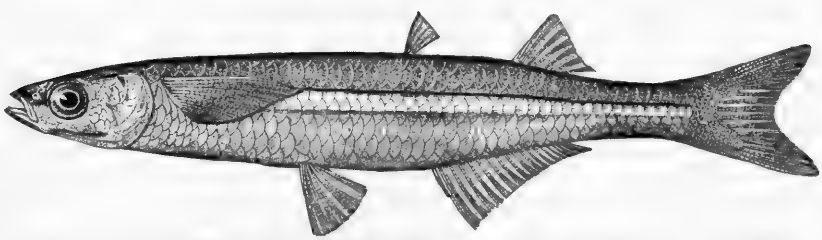


Fig. 171.—Silverside or Brit, *Kirtlandia vagrans* (Goode & Bean). Pensacola.

Kirtlandia laciniata, with ragged scales, is common along the Virginia coast, and *K. vagrans* farther south. Another small species, very slender and very graceful, is the brook silver-

side *Labidesthes sicculus*, which swarms in clear streams from Lake Ontario to Texas. This species, three to four inches long, has the snout produced and a very bright silvery stripe along the side. Large and small species of silversides occur

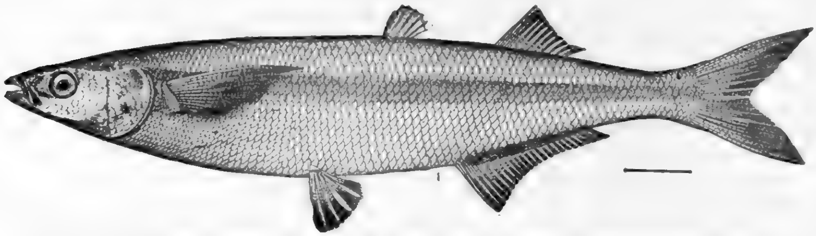


FIG. 172.—Blue Smelt or Pez del Rey, *Atherinopsis californiensis* Girard. San Diego.

in the sea along the California coast, where they are known familiarly as "blue smelt" or "Peixe Re." The most important of these and the largest member of the family, reaching a length of eighteen inches, is *Atherinopsis californiensis*, an important food-fish throughout California, everywhere wrongly known as smelt. *Atherinops affinis* is much like it, but has

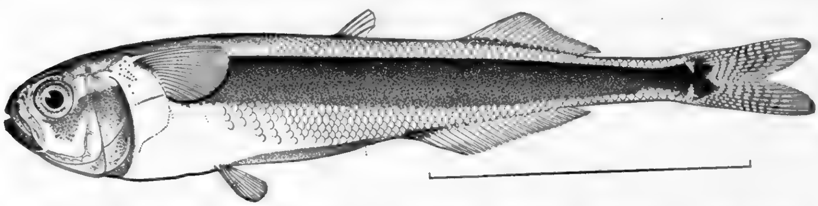


FIG. 173.—Flower of the waves, *Iso flos-maris*, Jordan & Starks. Enoshima, Japan.

Y-shaped teeth. *Iso flos-maris*, called Nami-no-hana, or flower of the surf, is a shining little fish with belly sharp like that of a herring. It lives in the surf on the coast of Japan. *Melanotænia nigrans* of Australia (family *Melanotæniidæ*) has the lateral band jet-black, as has also *Melaniris balsanus* of the rivers of southern Mexico. *Atherinosoma vorax* of Australia has strong teeth like those of a barracuda.

Fossil species of *Atherina* occur in the Italian Eocene, the best known being *Atherina macrocephala*. Another species, *Rhamphognathus paralepoides*, allied to *Menidia*, occurs in the Eocene of Monte Bolca.

The Mullets: Mugilidæ.—The mullets (*Mugilidæ*) are more clumsy in form than the silversides, robust, with broad heads and stouter fin-spines. The ventral fins are abdominal but well forward, the pelvis barely touching the clavicle, a condition to be defined as "subabdominal." The small mouth is armed with very feeble teeth, often reduced to mere fringes. The stomach is muscular like the gizzard of a fowl and the species feed largely on the vegetation contained in mud. There are numerous species, mostly living in shallow bays and estuaries, but some of them are confined to fresh waters. All are valued as food and some of them under favorable conditions are especially excellent.

Most of the species belong to the genera *Mugil*, the mullet of all English-speaking people, although not at all related to the red mullet or surmullet of the ancient Romans, *Mullus barbatus*.

The mullets are stoutish fish from one to two feet long, with blunt heads, small mouths almost toothless, large scales, and a general bluish-silvery color often varied by faint blue stripes. The most important species is *Mugil cephalus*, the common striped mullet This is found throughout southern Europe and from Cape Cod to Brazil, from Monterey, California, to Chile, and across the Pacific to Hawaii, Japan, and the Red Sea. Among specimens from all these regions we can detect no difference.

Professor Goode gives the following account of its habits:

"The large mullets begin to assemble along the Florida coast in schools in the height of summer, probably preparatory to spawning, and at this time the eggs commence to mature. In this season they swim at the surface, and are then pursued by enemies in the water and the air, and also fall an easy prey to the fishermen. They appear to prefer to swim against the wind, and school best with a northeast wind. They also run against the tide. In Florida the spawning season seems to extend from the middle of November to the middle of January. Some of the fishermen say that they go on the mud-flats and oyster-beds at the mouth of the river to deposit their eggs. What becomes of them after this no one seems to know, but it is probable that they spread themselves over the whole surface of water-covered country in such a manner as not to be

perceptible to the fisherman, who makes no effort at this time to secure the spent, lean fish. Many of them probably find their way to the lakes and others remain wherever they find good feeding-ground, gathering flesh and recruiting strength for the great strain of the next spawning season."

Professor Goode informs us that the fishermen recognize "three distinct periods of schooling and separate runs of mullet. To what extent these are founded on tradition, or upon the necessity of change in the size of the mesh of their nets, it is impossible to say. The 'June mullet' average about five to the pound; the 'fat mullet,' which are taken from August 20 to October 1, weigh about two pounds; these have, the fishermen say, a 'roe of fat' on each side as thick as a man's thumb. The 'roe mullet' weigh about two and a half pounds and are caught in November and until Christmas. Between the seasons of 'fat mullet' and 'roe mullet' there is an intermission of two or three weeks in the fishing." Professor Goode hazards the suggestion that "the 'fat mullet' of September are the breeding fish of November, with roes in an immature state, the ova not having become fully differentiated."

The mullet feed on the bottom in quiet water, swimming head downward. The food is sifted over in the mouth, the mud rejected, and the plants, chiefly microscopic, retained. Mr. Silas Stearns compares a school of mullets to barnyard fowls feeding together. When a fish finds a rich spot the others flock about it as chickens do. The pharyngeals form a sort of filter, stopping the sand and mud, the coarse parts being ejected through the mouth. Dr. Günther thus describes this apparatus:

"The upper pharyngeals have a rather irregular form: they are slightly arched, the convexity being directed toward the pharyngeal cavity, tapering anteriorly and broad posteriorly. They are coated with a thick, soft membrane, which reaches far beyond the margin of the bone and is studded all over with minute horny cilia. Each branchial arch is provided with a series of long gill-rakers, which are laterally bent downward, each series closely fitting to the sides of the adjoining arch; they constitute together a sieve admirably adapted to permit a transit for the water, retaining at the same time every solid substance in the cavity of the pharynx."

The young mullet feed in schools and often swim with the head at the surface of the water.

We are not able to distinguish from the common striped mullet of Europe and America the mullet of Hawaii, the famous Ama-ama, the most valued of Hawaiian fishes. This species is reared in mullet ponds, made by extending a stone wall across an arm of the sea. Through openings in the wall the young mullet enter, and in its protection they grow very fat on the abundant algæ and other vegetation. They thus become the most plentiful and most esteemed of the market fishes of Honolulu. The Awa (*Chanos*) and the Awa-awa (*Elops*) also enter these ponds and are reared with the mullet, being

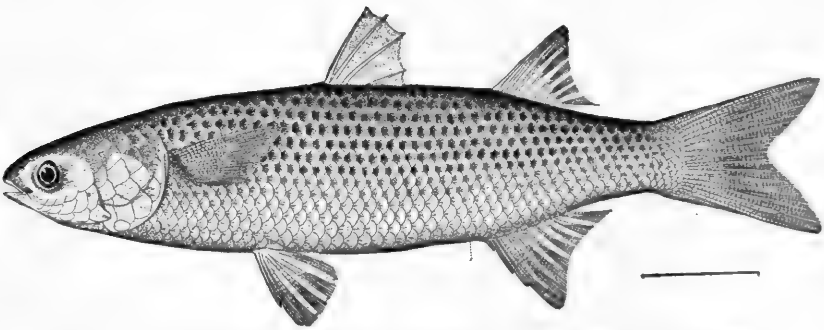


Fig. 174.—Striped Mullet, *Mugil cephalus* (L.). Wood's Hole, Mass.

similarly but less valued. Unfortunately the kaku, or small barracuda (*Sphyræna helleri*), also enters with these helpless fishes and destroys many of the smaller individuals. Another striped species, also very similar to *Mugil cephalus* in appearance and value, in fact indistinguishable from the Hawaiian mullet, abounds in Japan and India.

The white or unstriped mullets are generally smaller, but otherwise differ little. *Mugil curema* is the white mullet of tropical America, ranging occasionally northward, and several other species occur in the West Indies and the Mediterranean. The genus *Mugil* has the eye covered by thick transparent tissue called the adipose eyelid. In *Liza* the adipose eyelid is wanting. *Liza capito*, the big-headed mullet of the Mediterranean, is a well-known species. Most of the mullets of the south seas belong to the genus *Liza*. *Liza melinoptera* and *Liza*

cæruleomaculata are common in Samoa. The genus *Querimana* includes dwarf-mullets, two or three inches long, known as whirligig-mullets. These little fishes gather in small schools and swim round and round on the surface like the whirligig-beetles, or *Gyrinidæ*, their habits being like those of the young mullets; some young mullets having been, in fact, described as species of *Querimana*. The genus *Agonostomus* includes fresh-water mullets of the mountain rivers of the East and West Indies and Mexico, locally known as trucha, or trout. *Agonostomus nasutus* of Mexico is the best-known species.

The Joturo, or Bobo, *Joturus pichardi*, is a very large robust and vigorous mullet which abounds at the foot of waterfalls

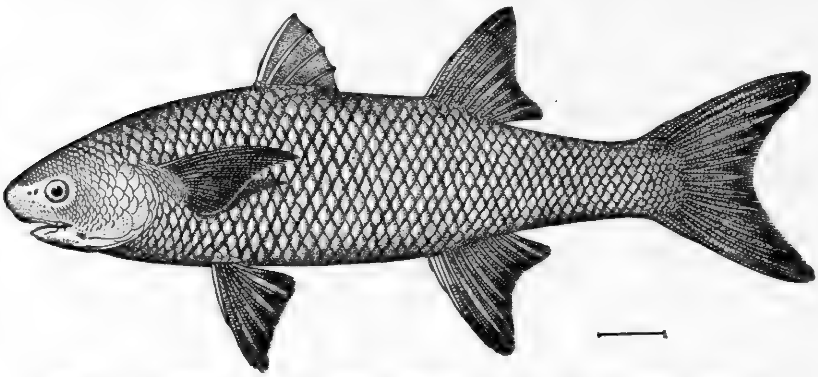


FIG. 175.—Joturo or Bobo, *Joturus pichardi* Poey. Rio Bayano, Panama.

in the mountain torrents of Cuba, eastern Mexico, and Central America. It is a good food-fish, frequently taken about Jalapa, Havana, and on the Isthmus of Panama. Its lips are very thick and its teeth are broad, serrated, loosely inserted incisors.

Fossil mullets are few. *Mugil radobojanus* is the earliest from the Miocene of Croatia.

The Barracudas: Sphyrænidæ.—The *Sphyrænidæ*, or barracudas, differ from the mullets in the presence of very strong teeth in the bones of the large mouth. The lateral line is also developed, there is no gizzard, and there are numerous minor modifications connected with the food and habits. The species are long, slender swift fishes, powerful in swimming and voracious to the last degree. Some of the species reach a length of six feet or more, and these are almost as dangerous to bathers

as sharks would be. The long, knife-like teeth render them very destructive to nets. The numerous species are placed in the single genus *Sphyræna*, and some of them are found in all warm seas, where they feed freely on all smaller fishes, their habits in the sea being much like those of the pike in the lakes. The flesh is firm, delicate, and excellent in flavor. In the larger species, especially in the West Indies, it may be difficult of digestion and sometimes causes serious illness, or "ichthyosism."

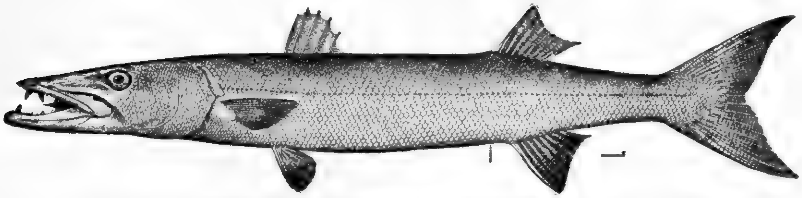


FIG. 176.—Barracuda, *Sphyræna barracuda* Walbaum. Florida.

Sphyræna sphyræna is the spet, or sennet, a rather small barracuda common in southern Europe. *Sphyræna borealis* of our eastern coast is a similar but still feebler species rarely exceeding a foot in length. These and other small species are feeble folk as compared with the great barracuda (*Sphyræna barracuda*) of the West Indies, a robust savage fish, also known as picuda or becuna. *Sphyræna commersoni* of Polynesia is a similar large species, while numerous lesser ones occur through the tropical seas. On the California coast *Sphyræna argentea* is an excellent food-fish, slenderer than the great barracuda but reaching a length of five feet.

Several species of fossil barracuda occur in the Italian Eocene, *Sphyræna bolcensis* being the earliest.

Stephanoberycidæ.—We may append to the *Percesoces*, for want of a better place, a small family of the deep sea, its affinities at present unknown. The *Stephanoberycidæ* have the ventrals I, 5, subabdominal, a single dorsal without spine, and the scales cycloid, scarcely imbricated, each with one or two central spines. The mouth is large, with small teeth, the skull cavernous, as in the berycoids, from which group the normally formed ventrals abdominal in position would seem to exclude it. *Stephanoberyx monæ* and *S. gilli* are found at the depth of a mile and a half below the Gulf Stream. Boulenger first placed

them with the *Percesoces*, but more recently suggests their relationship with the *Haplomi*. Perhaps, as supposed by Gill, they may prove to be degenerate berycoids in which the ventral fins have lost their normal connection.

Crossognathidæ. — A peculiar primitive group referred by Woodward to the *Percesoces* is the family of *Crossognathidæ* of the Cretaceous period. As in these fishes there are no fin-spines, they may be perhaps better placed with the *Haplomi*. The dorsal fin is long, without distinct spines, and the abdominal ventrals have six to eight rays. The mouth is small, with feeble teeth, and the body is elongate and compressed. *Crossognathus sabandianum* occurs in the Cretaceous of Switzerland and Germany, *Syllæmus latifrons* and other species in the Colorado Cretaceous, and *Syllæmus anglicus* in England. The *Crossognathidæ* have probably the lower pharyngeals separate, else they would be placed among the *Synentognathi*, a group attached by Woodward, not without reason, to the *Percesoces*.

Cobitopsidæ.—Near the *Crossognathidæ* may be placed the extinct *Cobitopsidæ*, *Cobitopsis acuta* being recorded from the

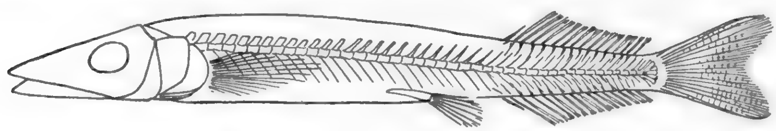


FIG. 177.—*Cobitopsis acuta* Gervais, restored. Oligocene of Puy-de-Dôme. (After Woodward.)

Oligocene of Puy-de-Dôme in France. In this species there is a short dorsal fin of about seventeen rays, no teeth, and the well-developed ventral fins are not far in front of the anal. This little fish bears a strong resemblance to *Ammodytes*, but the affinities of the latter genus are certainly with the ophidioid fishes, while the real relationship of *Cobitopsis* is uncertain.

Suborder Rhegnopteri.—The threadfins (*Polynemidæ*) are allied to the mullets, but differ from them and from all other fishes in the structure of the pectoral fin and its basal bones, or actinosts.

The pectoral fin is divided into two parts, the lower composed of free or separate rays very slender and thread-like,

sometimes longer than the body. Two of the actinosts of the pectoral support the fin, one is slender and has no rays, while the fourth is plate-like and attached to the coracoids, supporting the pectoral filaments. The body is rather robust, covered with large scales, formed much as in the mullet. The lateral

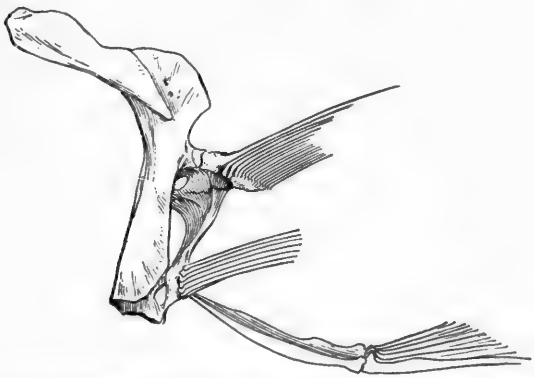


Fig. 178.—Shoulder-girdle of a Threadfin, *Polydactylus approximans* (Lay & Bennett).

line extends on the caudal fin as in the *Sciænidæ*, which group these fishes resemble in many ways. The mouth is large, inferior, with small teeth. The species are carnivorous fishes of excellent flesh, abounding on sandy shores in the warm seas. They are not very active and not at all voracious. The

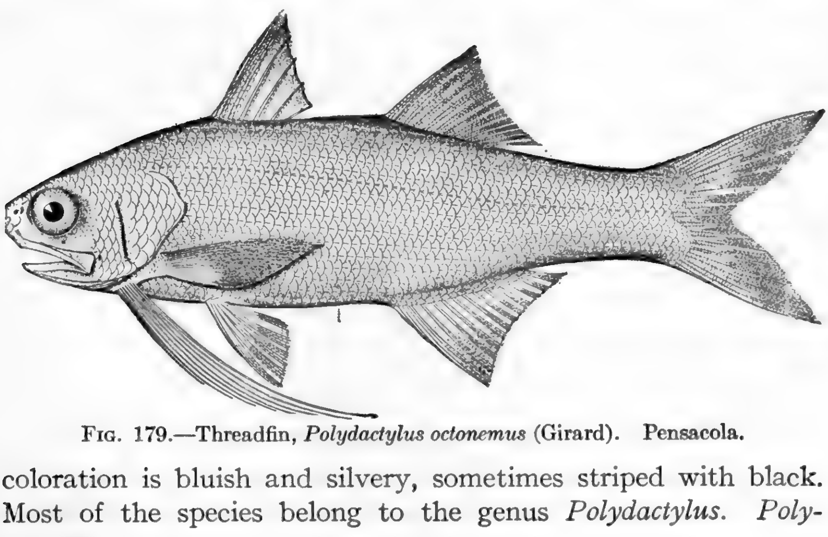


Fig. 179.—Threadfin, *Polydactylus octonemus* (Girard). Pensacola.

coloration is bluish and silvery, sometimes striped with black. Most of the species belong to the genus *Polydactylus*. *Poly-*

dactylus virginicus, the barbudo, with seven filaments, is common in the West Indies and Florida. *Polydactylus octonemus* with eight filaments is more rare, but ranges further north. *Polydactylus approximans*, the raton of western Mexico, with six filaments, reaches San Diego. *Polydactylus plebejus* is common in Japan and other species range through Polynesia. In India isinglass is made from the large air-bladder of species of *Polydactylus*. The rare *Polynemus quinquarius* of the West Indies have five pectoral filaments, these being greatly elongate, much longer than the body.

No extinct *Polynemidæ* are recorded.

CHAPTER XIII

PHTHINOBRANCHII: HEMIBRANCHII, LOPHOBRANCHII, AND HYPOSTOMIDES

SUBORDER **Hemibranchii.**—Still another transitional group, the *Hemibranchii*, is composed of spiny-rayed fishes with abdominal ventrals. In this suborder there are other points of divergence, though none of high importance. In these fishes the bones of the shoulder-girdle are somewhat distorted, the supraclavicle reduced or wanting, and the gill structures somewhat degenerate. The presence of bones called interclavicles or infraclavicles, below and behind the clavicle, has been supposed to characterize the order of *Hemibranchii*. But this character has very slight importance. In two families, *Macrorhamphosidæ* and *Centriscidæ*, the interclavicles are absent altogether. In the *Fistulariidæ* they are very large. According to the studies of Mr. Edwin C. Starks,

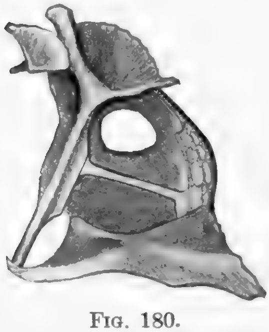


FIG. 180.

FIG. 181.

FIG. 180.—Shoulder-girdle of a Stickleback, *Gasterosteus aculeatus* Linnæus. (After Parker.)

FIG. 181.—Shoulder-girdle of *Fistularia petimba* Lacépède, showing greatly extended interclavicle, the surface ossified.

the bone in question is not a true infraclavicle. It is not identical with the infraclavicle of the Ganoids, but it is only a backward extension of the hypocoracoid, there being no suture between

the two bones. In those species which have bony plates instead of scales, this bone has a deposit of bony substance or ganoid enamel at the surface. This gives it an apparent prominence as compared with other bones of the skeleton, but it has no great taxonomic importance. Dr. Hay unites the suborders *Hemibranchii*, *Lophobranchii*, and *Hypostomides* to form the order *Phthinobranchii* (φθινάς, waning; βράγχος, gill), characterized by the reduction of the gill-arches. These forms are really nearly related, but their affinities with the *Percesoces* are so close that it may not be necessary to form a distinct order of the combined group. Boulenger unites the *Hemibranchii* with *Lampris* to form a group, *Catosteomi*, characterized by the development of infraclavicles; but we cannot see that *Lampris* bears any affinity to the sticklebacks, or that the presence of infraclavicle has any high significance, nor is it the supposed infraclavicle of *Lampris* homologous with that of the *Hemibranchii*. The dorsal fin in the *Hemibranchii* has more or less developed spines; spines are also present in the ventral fins. The lower pharyngeals are separated; there is no air-duct. The mouth is small and the bones of the snout are often much produced. The preopercle and symplectic are distinct. The group is doubtless derived from some transitional spiny-rayed type allied to the *Percesoces*. The Lophobranchs, another supposed order, represent simply a still further phase of degradation of gills and ventral fins. Dr. Gill separates these two groups as distinct orders and places them, as aberrant offshoots, near the end of his series of bony fishes. We prefer to leave them with the other transitional forms, not regarding their traits of divergence as of any great importance in the systematic arrangement of families.

The Sticklebacks: Gasterosteidæ. — The sticklebacks (*Gasterosteidæ*) are small, scaleless fishes, closely related to the *Fistulariidæ* so far as anatomy is concerned, but with very different appearance and habits. The body often mailed, the dorsal is preceded by free spines and the ventrals are each reduced to a sharp spine with a rudimentary ray. The jaws are short, bristling with sharp teeth, and these little creatures are among the most active, voracious, and persistent of all fishes. They attack the fins of larger fishes, biting off pieces,

and at the same time they devour the eggs of all species accessible to them. In almost all fresh and brackish waters of the north temperate zone these little fishes abound. "It is scarcely to be conceived," Dr. Günther observes, "what damage these little fishes do, and how greatly detrimental they are to the increase of all the fishes among which they live, for it is with the utmost industry, sagacity, and greediness that they seek out and destroy all the young fry that come their way."

The sticklebacks inhabit brackish and fresh waters of the northern hemisphere, species essentially alike being found throughout northern Europe, Asia, and America. The same species is subject to great variation. The degree of development of spines and bony plates is greatest in individuals living in the sea and least in clear streams of the interior. Each of the mailed species has its series of half-mailed or even naked varieties found in the fresh waters. This is true in Europe, New England, California, and Japan. The farther the individuals are from the sea, the less perfect is their armature. Thus, *Gasterosteus cataphractus*, which in the sea has a full armature of bony plates on the side, about 30 in number, will have in river mouths from 6 to 20 plates and in strictly fresh water only 2 or 3 or even none at all.

The sticklebacks have been noted for their nest-building habits. The male performs this operation, and he is provided with a special gland for secretion of the necessary cement. Dr. Gill quotes from Dr. John A. Ryder an account of this process. The secretory gland is a "large vesicle filled with a clear secretion which coagulates into threads upon contact with water. It appears to open directly in front of the vent. As soon as it is ruptured, it loses its transparency, and whatever secretion escapes becomes whitish after being in contact with water for a short time. This has the same tough, elastic qualities as when spun by the animal itself, and is also composed of numerous fibers, as when a portion is taken that has been recently spun upon the nest. Thus provided, when the nuptial season has arrived the male stickleback prepares to build his nest, wherein his mate may deposit her eggs. How this nest is built, and the subsequent proceedings of the sticklebacks, have been told us in a graphic manner by Mr. John K.

Lord, from observations on *Gasterosteus cataphractus* on Vancouver Island, although the source of his secretion was misunderstood:

"The site is generally amongst the stems of aquatic plants, where the water always flows but not too swiftly. He first begins by carrying small bits of green material which he nips off the stalks and tugs from out the bottom and sides of the bank; these he attaches by some glutinous material, that he clearly has the power of secreting, to the different stems destined as pillars for his building. During this operation he swims against the work already done, splashes about, and seems to test its durability and strength; rubs himself against the tiny kind of platform, scrapes the slimy mucus from his sides to mix with and act as mortar for his vegetable bricks. Then he thrusts his nose into the sand at the bottom, and, bringing a mouthful, scatters it over the foundation; this is repeated until enough has been thrown on to weight the slender fabric down and give it substance and stability. Then more twists, turns, and splashings to test the firm adherence of all the materials that are intended to constitute the foundation of the house that has yet to be erected on it. The nest, or nursery, when completed is a hollow, somewhat rounded, barrel-shaped structure worked together much in the same way as the platform fastened to the water-plants; the whole firmly glued together by the viscous secretion scraped from off the body. The inside is made as smooth as possible by a kind of plastering system; the little architect continually goes in, then, turning round and round, works the mucus from his body on to the inner sides of the nest, where it hardens like tough varnish. There are two apertures, smooth and symmetrical as the hole leading into a wren's nest, and not unlike it.

"All this laborious work is done entirely by the male fish, and when completed he goes a-wooing. Watch him as he swims towards a group of the fair sex enjoying themselves amidst the water-plants arrayed in his best and brightest livery, all smiles and amiability; steadily and in the most approved style of stickleback love-making this young and wealthy bachelor approaches the object of his affections, most likely tells her all about his house and its comforts, hints

delicately at his readiness and ability to defend her children against every enemy, vows unfailing fidelity, and in lover fashion promises as much in a few minutes as would take a lifetime to fulfill. Of course she listens to his suit; personal beauty, indomitable courage, backed by the substantial recommendations of a house ready built and fitted for immediate occupation, are gifts not to be lightly regarded.

"Throwing herself on her side the captive lady shows her appreciation, and by sundry queer contortions declares herself his true and devoted spouse. Then the twain return to the nest, into which the female at once betakes herself and therein deposits her eggs, emerging, when the operation is completed, by the opposite hole. During the time she is in the nest (about six minutes) the male swims round and round, butts and rubs his nose against it, and altogether appears to be in a state of defiant excitement. On the female leaving, he immediately enters, deposits the milt on the eggs, taking his departure through the back door. So far his conduct is strictly pure; but I am afraid morality in stickleback society is of rather a lax order. No sooner has this lady, his first love, taken her departure, than he at once seeks another, introduces her as he did the first, and so on, wife after wife, until the nest is filled with eggs, layer upon layer, milt being carefully deposited betwixt each stratum of ova. As it is necessary there should be two holes, by which ingress and egress can be readily accomplished, so it is equally essential in another point of view. To fertilize fish-eggs, running water is the first necessity; and, as the holes are invariably placed in the direction of the current, a steady stream of water is thus directed over them."

To the genus *Gasterosteus* the largest species belong, those having three dorsal spines, and the body typically fully covered with bony plates. *Gasterosteus aculeatus* inhabits both shores of the Atlantic and the scarcely different *Gasterosteus cataphractus* swarms in the inlets from southern California to Alaska, Siberia, and northern Japan. Half-naked forms have been called by various names and one entirely naked in streams of southern California is named *Gasterosteus williamsoni*. Its traits are, however, clearly related to its life in fresh waters.

In *Pygosteus pungitius*, a type of almost equally wide range,

there are nine or ten dorsal spines and the body is more slender. All kinds of waters of the north on both continents may yield

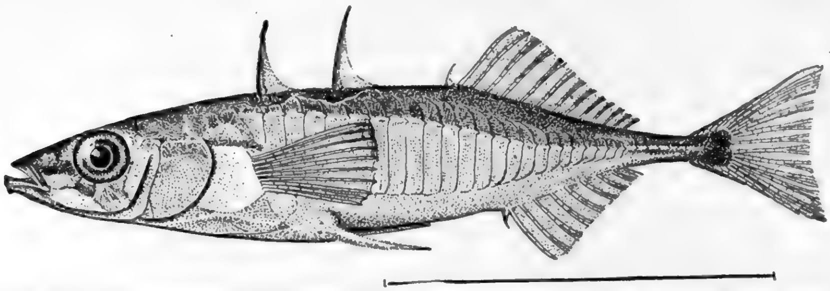


FIG. 182.—Three-spined Stickleback, *Gasterosteus aculeatus* L. Wood's Hole, Mass.

this species or its allies and variations, mailed or naked. The naked, *Apeltes quadracus*, is found in the sea only, along the New England coast.

Eucalia inconstans is the stickleback of the clear brook from New York to Indiana and Minnesota. The male is jet

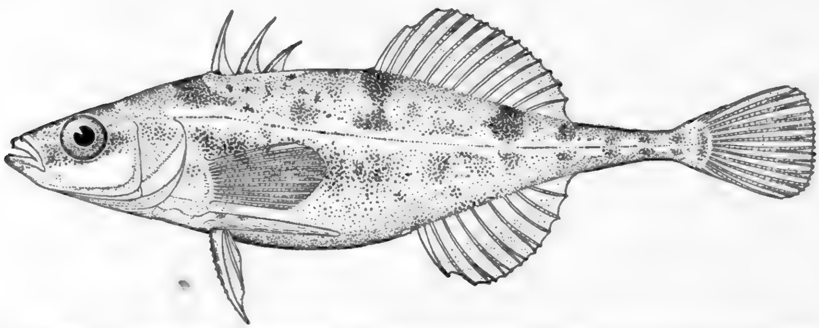


FIG. 183.—Four-spined Stickleback, *Apeltes quadracus* Mitchill. Wood's Hole, Mass

black in spring with the sheen of burnished copper and he is intensely active in his work of protecting the eggs of his own species and destroying the eggs and fry of others. *Spinachia spinachia* is a large sea stickleback of Europe with many dorsal spines.

No fossil *Gasterosteidæ* are recorded, and the family, while the least specialized in most regards, is certainly not the most primitive of the suborder.

The Aulorhynchidæ.—Closely related to the sticklebacks is the small family of *Aulorhynchidæ*, with four soft rays in the

ventral fins. *Aulorhynchus*, like *Spinachia*, has many dorsal spines and an elongate snout approaching that of a trumpet-fish. *Aulorhynchus flavidus* lives on the coast of California and *Aulichthys japonicus* in Japan. The extinct family of *Protosyngnathidæ* is near *Aulorhynchus*, with the snout tubular, the ribs free, not anchylosed as in *Aulorhynchus*, and with the first vertebræ fused, forming one large one as in *Aulostomus*. *Protosyngnathus sumatrensis* occurs in Sumatra. *Protaulopsis bolcensis* of the Eocene of Italy has the ventral fins farther back, and is probably more primitive than the sticklebacks.

Cornet-fishes: Fistulariidæ. — Closely related to the sticklebacks so far as structure is concerned is a family of very different habit, the cornet-fishes, or cornetas (*Fistulariidæ*). In these fishes the body is very long and slender, like that of a garfish. The snout is produced into a very long tube, which bears the short jaws at the end. The teeth are very small. There are no scales, but bony plates are sunk in the skin. The ventrals are abdominal, each with a spine and four rays. The four anterior vertebræ are very much elongate. There are no spines in the dorsal and the backbone extends through the forked caudal, ending in a long filament. The cornet-fishes are dull red or dull green in color. They reach a length of two or three feet, and the four or five known species are widely distributed through the warm seas, where they swim in shallow water near the surface. *Fistularia tabaccaria*, the tobacco-pipe fish, is common in the West Indies, *Fistularia petimba*, *F. serrata*, and others in the Pacific. A fossil cornet-fish of very small size, *Fistularia longirostris*, is known from the Eocene of Monte Bolca, near Verona. *Fistularia kœnigi* is recorded from the Oligocene of Glarus.

The Trumpet-fishes: Aulostomidæ.—The *Aulostomidæ*, or trumpet-fishes are in structure entirely similar to the *Fistulariidæ*, but the body is band-shaped, compressed, and scaly, the long snout bearing the feeble jaws at the end. There are numerous dorsal spines and no filament on the tail. *Aulostomus chinensis* (*maculatus*) is common in the West Indies, *Aulostomus valentini* abounds in Polynesia and Asia, where it is a food-fish of moderate importance. A species of *Aulostomus* (*bolcensis*) is found in the Italian Eocene. Allied to it is

the extinct family *Urosphenidæ*, scaleless, but otherwise similar. *Urosphen dubia* occurs in the Eocene at Monte Bolca. *Urosphen*

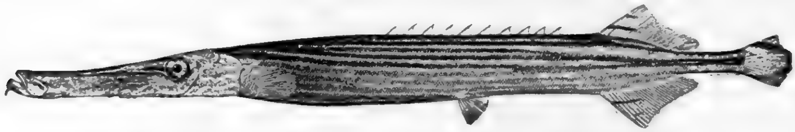


FIG. 184.—Trumpet-fish, *Aulostomus chinensis* (L.) Virginia.

is perhaps the most primitive genus of the whole suborder of *Hemibranchii*.

The Snipefishes: Macrorhamphosidæ.—Very remarkable fishes are the snipefishes, or *Macrorhamphosidæ*. In these forms

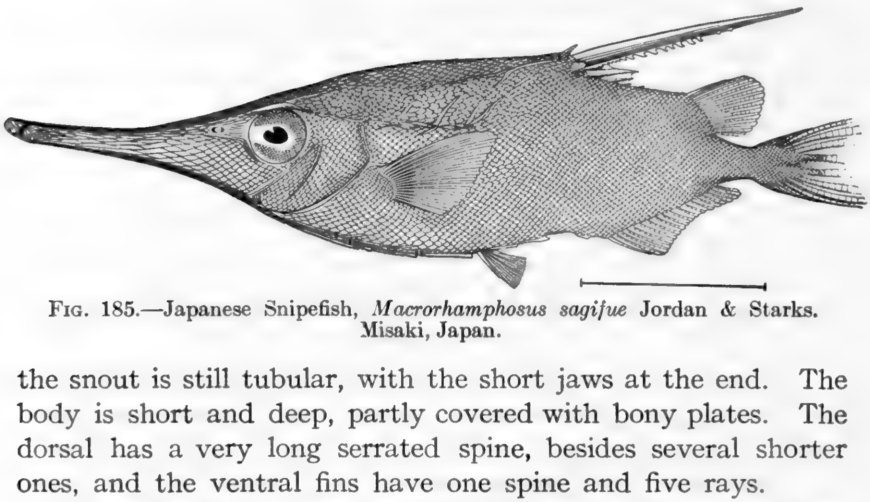


FIG. 185.—Japanese Snipefish, *Macrorhamphosus sagifue* Jordan & Starks. Misaki, Japan.

the snout is still tubular, with the short jaws at the end. The body is short and deep, partly covered with bony plates. The dorsal has a very long serrated spine, besides several shorter ones, and the ventral fins have one spine and five rays.

The snipefish, or woodcock-fish, *Macrorhamphosus scolopax*, is rather common on the coasts of Europe, and a very similar species (*M. sagifue*) occurs in Japan. The *Rhamphosidæ*, represented by *Rhamphosus*, an extinct genus with the ventrals further forward, are found in the Eocene rocks of Monte Bolca. *Rhamphosus vastrum* has minute scales, short dorsal, and the snout greatly attenuate.

The Shrimp-fishes: Centriscidæ.—One of the most extraordinary types of fishes is the small family of *Centriscidæ*, found in the East Indies. The back is covered by a transparent bony cuirass which extends far beyond the short tail, on which the two dorsal fins are crowded. Anteriorly this cuirass is

composed of plates which are soldered to the ribs. The small toothless mouth is at the end of a long snout.

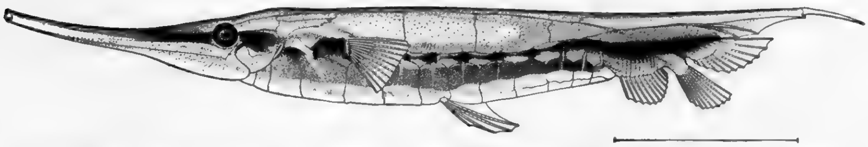


FIG. 186.—Shrimp-fish, *Æoliscus strigatus* (Günther). Riu Kiu Islands, Japan.

These little fishes with the transparent carapace look very much like shrimps. *Centriscus scutatus* (*Amphisile*) with the terminal spine fixed is found in the East Indies, and *Æoliscus strigatus* with the terminal spine movable is found in southern Japan and southwards.

A fossil species, *Æoliscus heinrichi*, is found in the Oligocene

FIG. 187.—*Æoliscus heinrichi* Heckel. Eocene of Carpathia. Family *Centriscidæ*. (After Heckel.)

of various parts of Europe, and *Centriscus longirostris* occurs in the Eocene of Monte Bolca.

In the *Centriscidæ* and *Macrorhamphosidæ* the expansions of the hypocoracoid called infraclavicles are not developed.

The Lophobranchs.—The suborder *Lophobranchii* (λοφός, tuft; βραγχός, gill) is certainly an offshoot from the *Hemibranchii* and belongs likewise among the forms transitional from soft to spiny-rayed fishes. At the same time it is a degenerate group, and in its modifications it turns directly away from the general line of specialization.

The chief characters are found in the reduction of the gills to small lobate tufts attached to rudimentary gill-arches. The so-called infraclavicles are present, as in most of the *Hemibranchii*. Bony plates united to form rings take the place of scales. The long tubular snout bears the short toothless jaws at the end. The preopercle is absent, and the ventrals are seven-rayed or wanting. The species known as pipefishes and sea-horses are all very small and none have any economic value. They are

numerous in all warm seas, mostly living in shallow bays among seaweed and eel-grass. The muscular system is little developed and all the species have the curious habit of carrying the eggs until hatched in a pouch of skin under the belly or tail; this structure is usually found in the male.

The Solenostomidæ. — The *Solenostomidæ* of the East Indies are the most primitive of these fishes. They have the body rather short and provided with spinous dorsal, and ventral fins. The pretty species are occasionally swept northward to Japan in the Black Current. *Solenostomus cyanopterus* is a characteristic species. *Solenorhynchus elegans*, now extinct (with the trunk more elongate), preceded *Solenostomus* in the Eocene of Monte Bolca.

The Pipefishes: Syngnathidæ.—The *Syngnathidæ* are very long and slender fishes, with neither spinous dorsal, nor ventral fins, the body covered by bony rings. Of the pipefish, *Syngnathus*, there are very many species on all northern coasts. *Syngnathus acus* is common in Europe, *Syngnathus fuscum* along the New England coast, *Syngnathus californiense* in California, and *Syngnathus schlegeli* in Japan. Numerous other species of *Syngnathus* and other genera are found further south in the same regions. *Corythroichthys* is characteristic of coral reefs and *Microphis* of the streams of the islands of Polynesia. In general, the more northerly species have the greater number of vertebræ and of bony rings. *Tiphle tiphle* is a large pipefish of the Mediterranean. This species was preceded by *Tiphle albyi* (*Siphonostoma*) in the Miocene of Sicily. Other pipefishes, referred to as *Syngnathus* and *Calamostoma*, are found as fossils in Tertiary rocks.

The Sea-horses: Hippocampus.—Both fossil and recent forms constitute a direct line of connection from the pipe-fishes to the sea-horses. In the latter the head has the form of the head of a horse. It is bent at right angles to the body like the head of a knight at chess. There is no caudal fin, and the tail in typical species is coiled and can hardly be straightened out. *Calamostoma* of the Eocene, *Gasterotokeus* of Polynesia, and *Acentronura* of Japan are forms which connect the true sea-horses with the pipefish. *Gasterotokeus* has the long head and slender body of the pipefish, with the prehensile finless

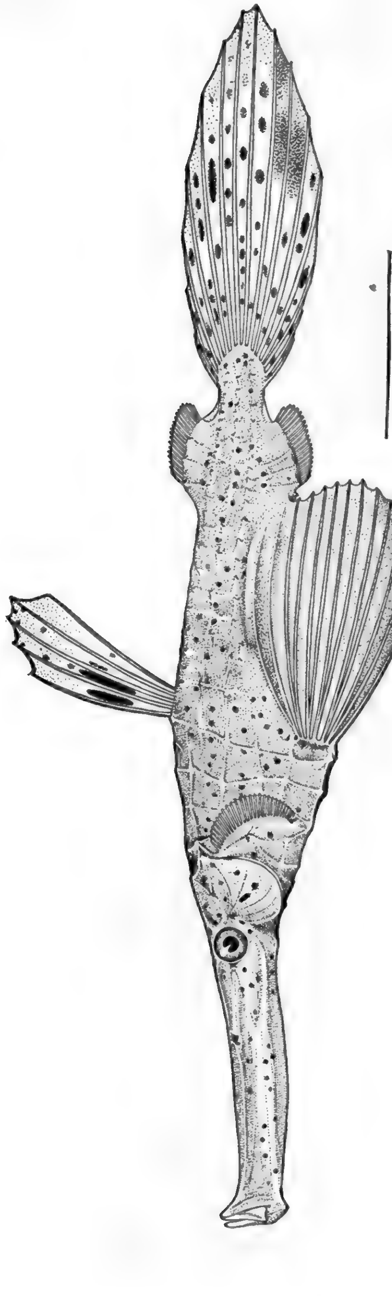


FIG. 188.—*Solenostomus cyanopterus* Bleeker. Misaki, Japan.

tail of a sea-horse. Most of the living species of the sea-horse belong to the genus *Hippocampus.* These little creatures have the egg-sac of the male under the abdomen. They range from two inches to a foot in length and some of the many species may be found in abundance in every warm sea. Some cling by the tails to floating seaweed and are swept to great distances; others cling to eel-grass and live very near the shore. The commonest European species is *Hippocampus hippocampus.* Most abundant on our Atlantic coast is *Hippocampus hudsonius. Hippocampus coronatus* is most common in Japan. The largest species are *Hippocampus ingens* of Lower California and *Hippocampus kelloggi* in Japan. Many species, especially of the smaller ones, have the spines of the bony plates of the body ending in fleshy flaps. These are sometimes so enlarged as to simulate leaves of seaweed, thus serving for the efficient protection of the species. These flaps are developed to an extreme degree in *Phyllopteryx eques*, a pipefish of the East Indies.

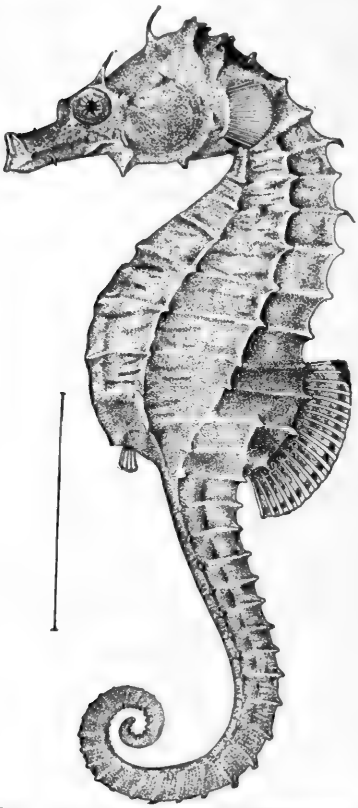


FIG. 189.—Sea-horse, *Hippocampus hudsonius* Dekay. Virginia.

No fossil sea-horses are known.

The following account of the breeding-habits of our smallest sea-horse (*Hippocampus zosteræ*) was prepared by the writer for a book of children's stories:

"He was a little bit of a sea-horse and his name was Hippocampus. He was not more than an inch long, and he had a red stripe on the fin on his back, and his head was made of bone and it had a shape just like a horse's head, but he ran out to a point at his tail, and his head and his tail were all covered with bone. He lived in the Grand Lagoon at Pensacola in Florida,

where the water is shallow and warm and there are lots of seaweeds. So he wound his tail around a stem of seaweed and hung with his head down, waiting to see what would happen next, and then he saw another little sea-horse hanging on another seaweed. And the other sea-horse put out a lot of little eggs, and the little eggs all lay on the bottom of the sea at the foot of the seaweed. So Hippocampus crawled down from the seaweed where he was and gathered up all those little eggs, and down on the under side of his tail where the skin is soft he made a long slit for a pocket, and then he stuffed all the eggs into this pocket and fastened it together and stuck it with some slime. So he had all the other sea-horse's eggs in his own pocket.

"Then he went up on the seawrack again and twisted his tail around it, and hung there with his head down to see what would happen next. The sun shone down on him, and by and by all the little eggs began to hatch out, and each one of the eggs was a little sea-pony, shaped just like a sea-horse. And when he hung there with his head down he could feel all the little sea-ponies squirming inside his pocket, and by and by they squirmed so much that they pushed the pocket open, and then every one crawled away from him, and he couldn't get them back, and so he went along with them and watched to see that nothing should hurt them. And by and by they hung themselves all up on the seaweeds, and they are hanging there yet. And so he crawled back to his own piece of seaweed and twisted his tail around it, and waited to see what would happen next. And what happened next was just the same thing over again."

Suborder Hypostomides, the Sea-moths: Pegasidæ.—The small suborder of *Hypostomides* (ὑπό, below; στόμα, mouth) consists of the family of *Pegasidæ*. These "sea-moths" are fantastic little fishes, probably allied to the sticklebacks, but wholly unique in form. The slender body is covered with bony plates, the gill-covers are reduced to a single plate. The small mouth underneath a long snout has no teeth. The preopercle and the symplectic are both wanting. The ventrals are abdominal, formed of two rays, and the very large pectoral fin is placed horizontally like a great wing.

The species, few in number, known as sea-moths and sea-dragons, rarely exceed four inches in length. They are found

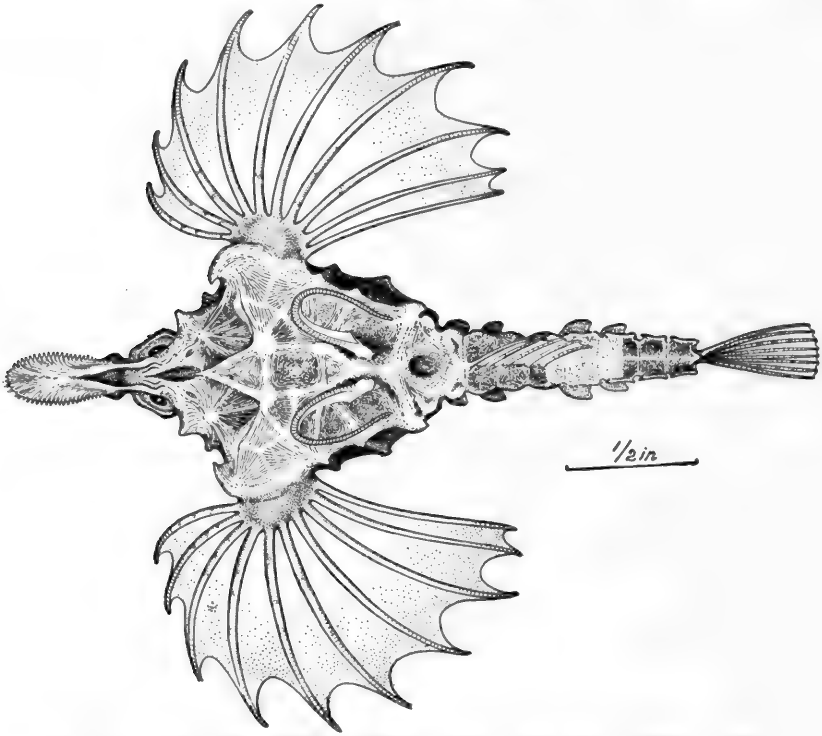


FIG 190.—Sea-moth, *Zalises umitengu* Jordan & Snyder. Misaki, Japan. (View from below.)

in the East Indies and drift with the currents northward to Japan. The genera are *Pegasus*, *Parapegasus*, and *Zalises*. The best-known species are *Zalises draconis* and *Pegasus volitans*.

No fossil species of *Pegasidæ* are known.

CHAPTER XIV

SALMOPERCÆ AND OTHER TRANSITIONAL GROUPS

SUBORDER Salmopercæ, the Trout-perches: Percopsidæ.—More ancient than the *Hemibranchii*, and still more distinctly in the line of transition from soft-rayed to spiny-rayed fishes, is the small suborder of *Salmopercæ*. This is characterized by the presence of the adipose fin of the salmon,

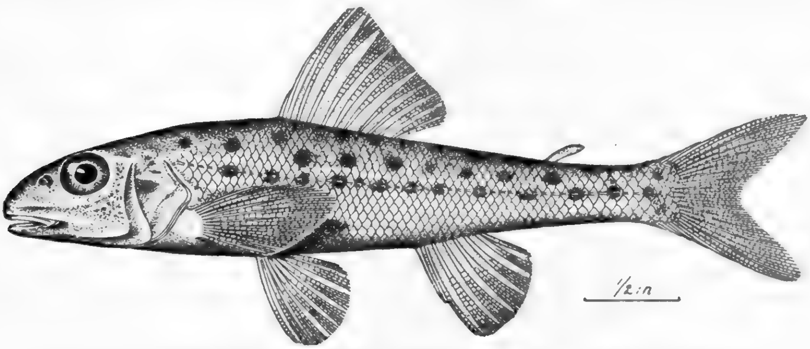


FIG. 191.—Sand-roller, *Pecropsis guttatus* Agassiz. Okoboji Lake, Ia.

in connection with the mouth, scales, and fin-spines of a perch. The premaxillary forms the entire edge of the upper jaw, the maxillary being without teeth. The air-bladder retains a rudimentary duct. The bones of the head are full of mucous cavities, as in the European perch called *Gymnocephalus* and *Acerina*. There are two spines in the dorsal and one or two in the anal, while the abdominal ventrals have each a spine and eight rays. Two species only are known among living fishes, these emphasizing more perfectly than any other known forms the close relation really existing between spinous and soft-rayed forms. The single family of *Percopsidæ* would seem to find its place in Cretaceous rocks rather than in the waters of to-day.

Percopsis guttata, the trout-perch or sand-roller of the Great Lakes, is a pale translucent fish with dark spots, reaching a length of six inches. It abounds in the Great Lakes and their tributaries and is occasionally found in the Delaware, Ohio,

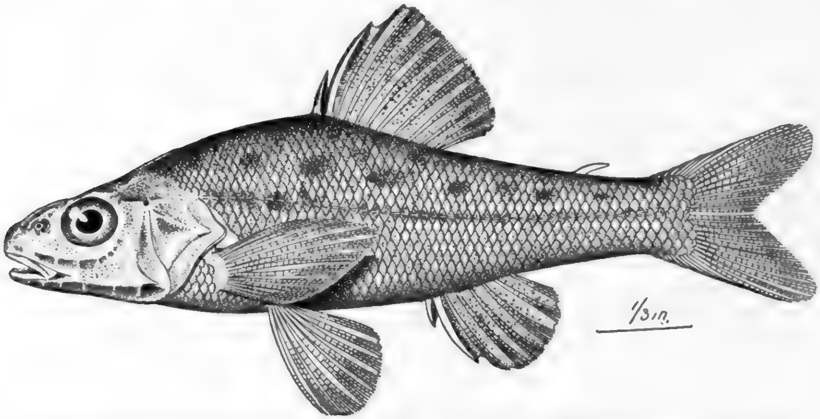


FIG. 192.—Oregon Trout-perch, *Columbia transmontana* Eigenmann. Umatilla River, Oregon.

Kansas, and other rivers and northwestward as far as Medicine Hat on the Saskatchewan. It is easily taken with a hook from the piers at Chicago.

Columbia transmontana is another little fish of similar type, but rougher and more distinctly perch-like. It is found in sandy or weedy lagoons throughout the lower basin of the Columbia, where it was first noticed by Dr. Eigenmann in 1892.

FIG. 193.—*Erismatopterus endlicheri* Cope. Green River Eocene. (After Cope.)

From the point of view of structure and classification, this left-over form is one of the most remarkable of American fishes.

Erismatopteridæ.—Here should perhaps be placed the family of *Erismatopteridæ*, represented by *Erismatopterus levatus* and other species of the Green River Eocene shales. In *Erismatopterus* the

short dorsal has two or three spines, there are two or three spines in the anal, and the abdominal ventrals are opposite the dorsal. Allied to *Erismatopterus* is *Amphiplaga* of the same deposits.

We cannot, however, feel sure that these extinct fragments, however well preserved, belonged to fishes having an adipose fin. Among spiny-rayed fishes the *Percopsidæ* alone retain this character, and the real affinities of *Erismatopterus* may be with *Aphredoderidæ* and other percoid forms.

The relations of the extinct family of *Asineopidæ* are also still uncertain. This group comprises fresh-water fishes said to be allied to the *Aphredoderidæ*, but with the pelvic bones not forked. *Asineops pauciradiata*, *squamifrons* and *viridensis* are described from the Green River shales. With *Erismatopterus* all these fishes may belong to the suborder of *Salmopercæ*, but, as above stated, the possession of the adipose fin, the most characteristic trait of the *Salmopercæ*, cannot be verified in the fossil remains.

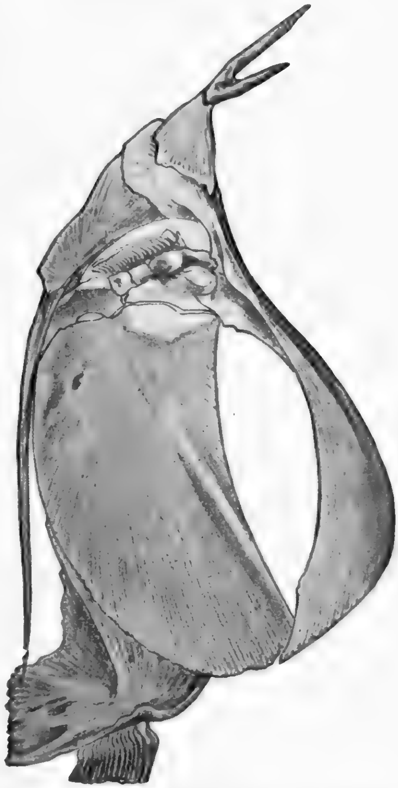


FIG. 194.—Shoulder-girdle of the Opah, *Lampris guttatus* (Brünnich), showing the enlarged infraclavicle. (After Boulenger.)

Suborder Selenichthyes, the Opahs: Lamprididæ.—We may bring together as constituting another suborder certain forms of uncertain relationship, but which seem to be transitional between deep-bodied extinct Ganoids and the forms allied to *Platax*, *Zeus*, and *Antigonia*. The name of *Selenichthyes* (σηλήνη, moon; ἰχθύς, fish) is suggested by Boulenger for the group of opahs, or moonfishes. These are characterized by the highly compressed body, the great development of a large hypocora-

coid, and especially by the structure of the ventral fins, which are composed of about fifteen rays instead of the one spine and five rays characteristic of the specialized perch-like fishes. The living forms of this type are further characterized by the partial or total absence of the spinous dorsal, by the small oblique mouth, and the prominence of the ventral curve of the body. A thorough study of the osteology of these forms living and fossil will be necessary before the group can be properly defined. The large bone above mentioned was at first considered by Boulenger as the interclavicle or infraclavicle, the hypocoracoid being regarded by him as displaced, lying with the actinosts. But it is certain, from the studies of Mr. Starks, that this bone is the real hypocoracoid, which in this case is simply exaggerated in size, but placed as in ordinary fishes.

The single living family, *Lampridida*, contains but one species, *Lampris guttatus*, known as opah, moonfish, mariposa, cravo, Jerusalem haddock, or San Pedro fish. This species reaches a length of six feet and a weight of 500 to 600 pounds. Fig. 199 (Vol. I) is taken from a photograph of an example weighing 317½ pounds taken near Honolulu by Mr. E. L. Berndt. The body is almost as deep as long, plump and smooth, without scales or bony plates. The vertebræ are forty-five in number, and the large ventrals contain about fifteen rays. The dorsal is without spines, the small mouth without teeth. The color is a "rich brocade of silver and lilac, rosy on the belly, everywhere with round silvery spots." The head and back have ultramarine tints, the jaws and fins are vermilion. On a drawing of this fish made at Sable Island in 1856, Mr. James Farquhar wrote (to Dr. J. Bernard Gilpin): "Just imagine the body, a beautiful silver interspersed with spots of a lighter color about the size of sixpence, the eyes very large and brilliant, with a golden ring around them. You will then have some idea of the splendid appearance of the fish when fresh. If Caligula had seen them I might have realized a fortune."

The skeleton of the opah is very firm and heavy. The flesh is of varying shades of salmon-red, tender, oily, and of a rich, exquisite flavor scarcely surpassed by any other fish whatsoever.

The opah is a rare fish, swimming slowly near the surface and ranging very widely in all the warm seas. It was first noticed in Norway by Gunner, the good bishop of Throndhjem, about 1780. It was soon after recorded from Elsinore, Torbay, and Madeira, and is occasionally taken in various places in Europe. It is also recorded from Newfoundland, Sable Island, Cuba, Monterey, San Pedro Point (near San Francisco), Santa Catalina, Honolulu, and Japan.

The specimen studied by the writer came ashore at Monterey in an injured condition, having been worsted in a struggle with some better-armed fish.

Allied to *Lampris* is the imposing extinct species known as *Semiophorus velifer* from the Eocene of Monte Bolca near Verona, the type of the extinct family of *Semiophoridæ*. This is a deep compressed fish, with very high spinous dorsal and very long, many-rayed ventrals. Other related species are known also from the Eocene. There is no evidence of any close relation between these fishes with *Caranx* or *Platax*, with which Woodward associates *Semiophorus*.

The *Semiophoridæ* differ from the *Lamprididæ* chiefly in the development of the spinous dorsal fin, which is composed of many slender rays.

Suborder Zeoidea.—Not far from the *Selenichthyes* and the *Berycoidei* we may place the singular group of John Dories, or zeoid fishes. These have the ventral fins thoracic and many-rayed, the dorsal fin provided with spines, and the post-temporal, as in the *Chætodontidæ*, fused with the skull. Dr. Boulenger calls attention to the close relation of these fishes to the flounders, and suggests the possible derivation of both from a synthetic type, the *Amphistiidæ*, found in the European Eocene. The *Amphistiidæ*, *Zeidæ*, and flounders are united by him to form the group or suborder *Zeorhombi*, characterized by the thoracic ventrals, which have the rays not I, 5 in number, by the progressive degeneration of the fin-spines and the progressive twisting of the cranium, bringing the two eyes to the same side of the head. It is not certain that the flounders are really derived from Zeus-like fishes, but no other guess as to their origin has more elements of probability.

FIG. 195.—*Semiophorus velifer* Volta. Eocene. (After Agassiz, per Zittel.)

We may, however, regard the *Zeoidea* on the one hand and the *Heterosomata* on the other as distinct suborders. This is

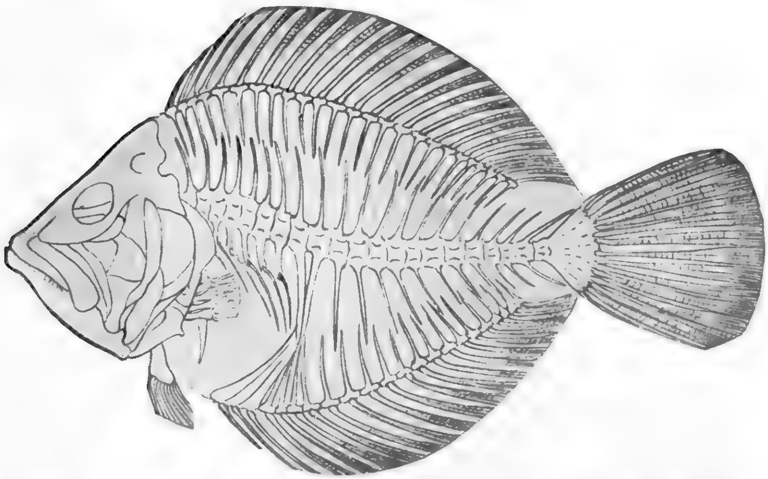


FIG. 196.—*Amphistium paradoxum* Agassiz. Upper Eocene, (Supposed ancestor of the flounders). (After Boulenger.)

certain, that the flounders are descended from spiny-rayed forms and that they have no affinities with the codfishes.

Amphistiidæ.—The *Amphistiidæ*, now extinct, are deep-bodied, compressed fishes, with long, continuous dorsal and anal in which a few of the anterior rays are simple, slender spines scarcely differentiated from the soft rays. The form of body and the structure of the fins are essentially as in the flounders, from which they differ chiefly by the symmetry of the head, the eyes being normally placed. *Amphistium paradoxum* is described by Agassiz from the upper Eocene. It occurs in Italy and France. In its dorsal and anal fins there are about twenty-two rays, the first three or four undivided. The teeth are minute or absent and there is a high supraoccipital crest.

The John Dories: Zeidæ.—The singular family of *Zeidæ*, or John Dories, agrees with Chætodonts in the single character of the fusion of the post-temporal with the skull. The species, however, diverge widely in other regards, and their ventral fins are essentially those of the Berycoids. In all the species there are seven to nine soft rays in the ventral fins, as in the Berycoid fishes. Probably the character of the fused

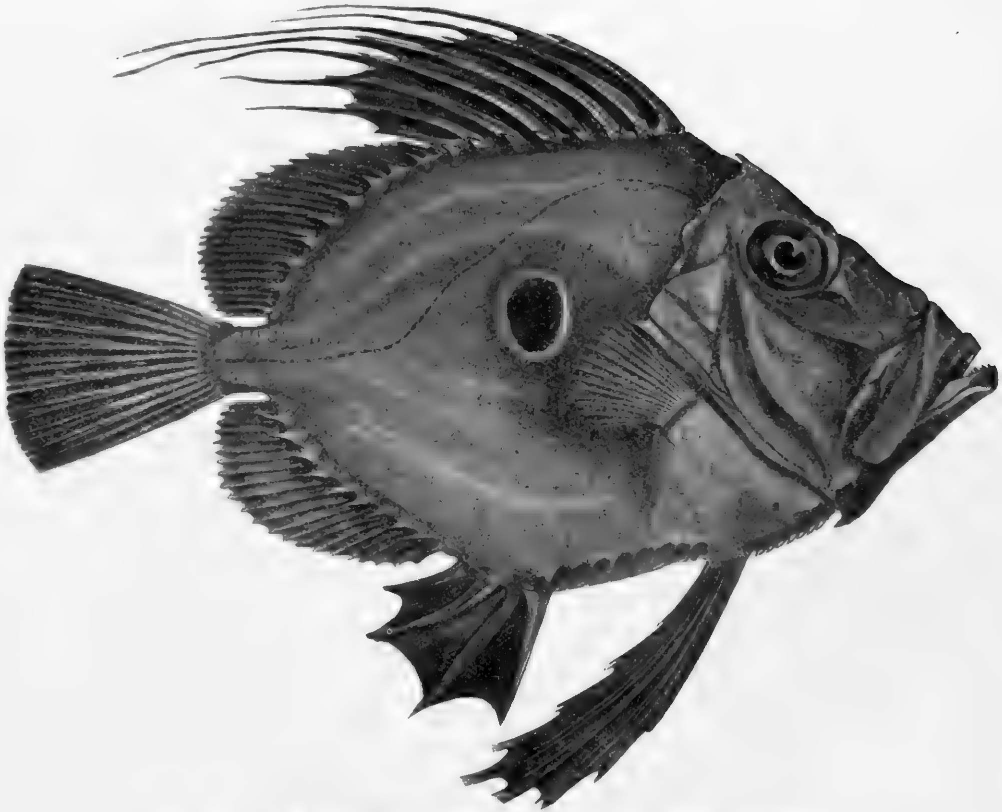


Fig. 197.—The John Dory, *Zeus faber*, Linnæus. Devon, England.

post temporal has been independently derived. The anterior vertebræ in *Zeus*, as in *Chætodon*, are closely crowded together. In the *Zeidæ* the spinous dorsal is well developed, the body naked or with very thin scales, and provided with bony warts at least around the bases of dorsal and anal fins. The species are mostly of small size, silvery in color, living in moderate depths in warm seas. The best-known genus is *Zeus*, which is a group of shore-fishes of the waters of Asia and Europe. The common John Dory (called in Germany Härings-König, or king of the herrings), *Zeus faber*, abounds in shallow bays on the coasts of Europe. It reaches a length of nearly a foot, and is a striking feature of the markets of southern Europe. The dorsal spines are high, the mouth large, and on the sides is a black ring, said by some to be the mark of the thumb of St. Peter, who is reported to have taken a coin from the mouth of this species. A black spot on several other species is associated with the same legend.

On the coasts of Japan abounds the Matao, or target-fish (*Zeus japonicus*), very similar to the European species and like it in form and color. *Zenopsis nebulosa* and *Zen itea* also occur on the coasts of Japan. The remaining *Zeidæ* (*Cyttus*, *Zenopsis*, *Zenion*, etc.) are all rare species occasionally dredged especially in the Australian region. *Zeus priscus* is recorded from the Tertiary, and *Cyttoides glaronensis* from the upper Eocene of Glavus.

Grammicolepidæ.—The *Grammicolepidæ*, represented by a single species, *Grammicolepis brachiusculus*, rarely taken off the coast of Cuba, is related to the *Zeidæ*. It has rough, ridged, parchment-like scales deeper than long. The ventrals are thoracic, with the rays in increased number, as in *Zeus* and *Beryx*, with each of which it suggests affinity.

CHAPTER XV

BERYCOIDEI

THE Berycoid Fishes. — We may place in a separate order a group of fishes, mostly spiny-rayed, which appeared earlier in geological time than any other of the spinous forms, and which in several ways represent the transition from the isospondylous fishes to those of the type of the mackerel and perch. In the berycoid fishes the ventral fins are always thoracic, the number of rays almost always greater than I, 5, and in all cases an orbitosphenoid bone is developed in connection with the septum between the orbits above. This bone is found in the *Isospondyli* and other primitive fishes, but according to the investigations of Mr. E. C. Starks it is wanting in all percoid and scombroid forms, as well as in the *Haplomi* and in all the higher fishes. This trait may therefore, among thoracic fishes, be held to define the section or suborder of *Berycoidei*.

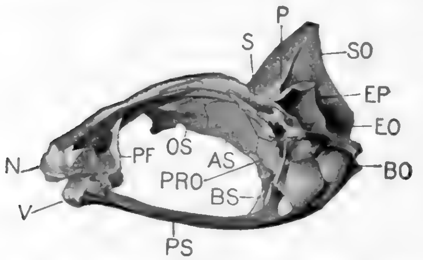


FIG. 198.—Skull of a Berycoid fish, *Beryx splendens* Cuv. & Val., showing the orbitosphenoid (OS), characteristic of all Berycoid fishes.

These fishes, most primitive of the thoracic types, were more abundant in Cretaceous and Eocene times than now. The possession of an increased number of soft rays in the ventral fins is archaic, although in one family, the *Monocentridæ*, the number is reduced to three. Most of the living *Berycoidei* retain through life the archaic duct to the air-bladder characteristic of most abdominal or soft-rayed fishes. In some however, the duct is lost. For the first time in the fish series the number of twenty-four vertebræ appears. In most spiny-

rayed fishes of the tropics, of whatever family, this number is retained.

In every case spines are present in the dorsal fin, and in certain cases the development of the spinous dorsal surpasses that of the most extreme perch-like forms. In geological times the Berycoids preceded all other perch-like fishes. They are probably ancestral to all the latter. All the recent species, in spite of high specialization, retain some archaic characters.

The Alfonsinos: Berycidæ.—The typical family, *Berycidæ*, is composed of fishes of rather deep water, bright scarlet or black in color, with the body short and compressed, the scales varying in the different genera. The single dorsal fin has a few spines in front, and there are no barbels. The suborbitals are not greatly developed.

The species of *Beryx*, called in Spanish *Alfonsino*, *Beryx elegans* and *Beryx decadactylus*, are widely distributed at moderate depths, the same species being recorded from Portugal, Madeira, Cuba, the Gulf Stream, and Japan. The colors are very handsome, being scarlet with streaks of white or golden. These fishes reach the length of a foot or more and are valued as food where sufficiently common.

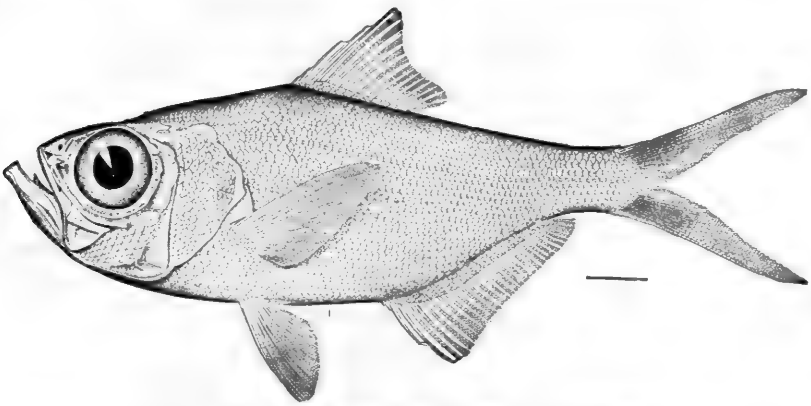


Fig. 199.—*Beryx splendens* Lowe. Gulf Stream.

Numerous species of *Beryx* and closely allied genera are found in all rocks since Cretaceous times; *Beryx dalmaticus*, from the Cretaceous of Dalmatia, is perhaps the earliest. *Beryx insculptus* is found in New Jersey, but no other Berycoids

are yet known as fossils from North America. *Sphenocephalus*, with four anal spines, is found in the chalk, as are also species of *Acrogaster* and *Pycnosterinx*, these being the earliest of fishes with distinctly spiny fins.

The *Trachichthyidæ* are deep-sea fishes with short bodies, cavernous skulls, and rough scales. The dorsal is short, with a few spines in front. The suborbitals are very broad, often covering the cheeks, and the anal fin is shorter than the dorsal, a character which separates these fishes from the *Berycidæ*, in

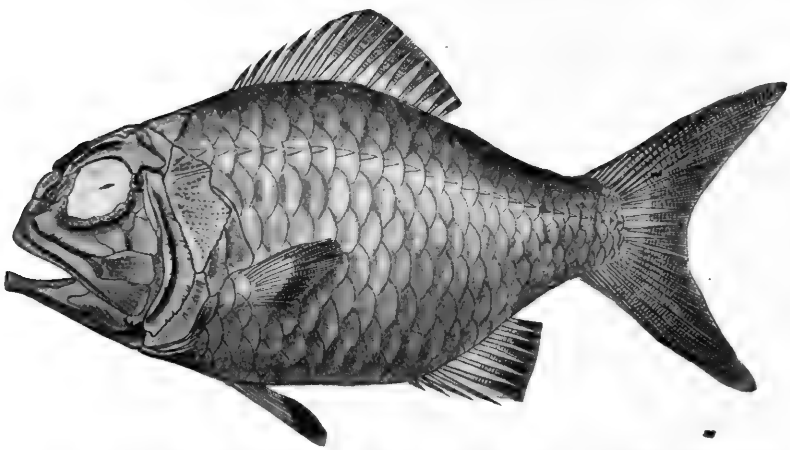


FIG. 200.—*Hoplopteryx lewesiensis* (Mantell), restored. English Cretaceous Family *Berycidæ*. (After Woodward.)

which group the anal fin is very long. The belly has often a serrated edge, and the coloration is red or black, the black species being softer in body and living in deeper water. Species of *Hoplostethus*, notably *Hoplostethus mediterraneus*, are found in most seas at a considerable depth. *Trachichthys*, a genus scarcely distinguishable from *Hoplostethus*, is found in various seas. The genus *Paratrachichthys* is remarkable for the anterior position of the vent, much as in *Aphredoderus*. Species occur in Japan and Australia. *Gephyroberyx*, with the dorsal fin notched, is known from Japan (*G. japonicus*) and Madeira (*G. darwini*).

We may also refer to the *Trachichthyidæ* certain species of still deeper waters, black in color and still softer in texture, with smaller scales which are often peculiar in form. These constitute the genera *Caulolepis*, *Anoplogaster*, *Melamphaës*,

and *Plectromus*. In *Caulolepis* the jaws are armed with very strong canines.

Allied to the *Trachichthyidæ* are also the fossil genera *Hoplopteryx* and *Homonotus*. *Hoplopteryx lewesiensis*, from the English chalk, is one of the earliest of the spiny-rayed fishes.

The Soldier-fishes: Holocentridæ.—The soldier-fishes (*Holocentridæ*), also known as squirrel-fishes, Welshmen, soldados, matajuelos, malau, alehi, etc., are shore fishes very characteristic

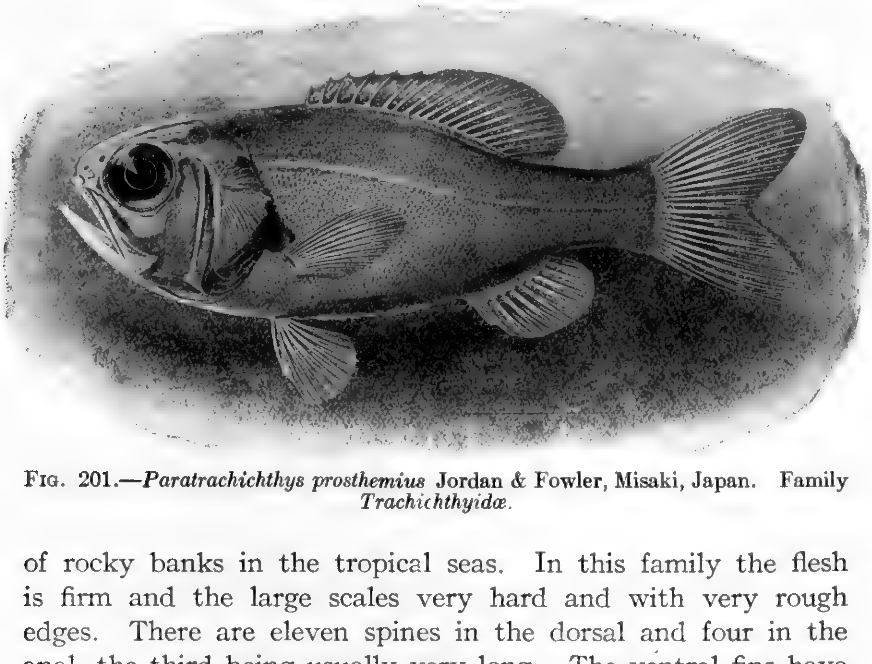


FIG. 201.—***Paratrachichthys prosthemius*** **Jordan & Fowler, Misaki, Japan. Family** ***Trachichthyidæ.***

of rocky banks in the tropical seas. In this family the flesh is firm and the large scales very hard and with very rough edges. There are eleven spines in the dorsal and four in the anal, the third being usually very long. The ventral fins have one spine and seven soft rays. The whole head and body are rough with prickles. The coloration is always brilliant, the ground hue being scarlet or crimson, often with lines or stripes of white, black, or golden. The fishes are valued as food, and they furnish a large part of the beauty of coloration so characteristic of the fishes of the coral reefs. The species are active, pugnacious, carnivorous, but not especially voracious, the mouth being usually small.

The genus *Holocentrus* is characterized by the presence of a large spine on the angle of the preopercle. Its species are

especially numerous, *Holocentrus ascenscionis*, abundant in Cuba, ranges northward in the Gulf Stream. *Holocentrus*

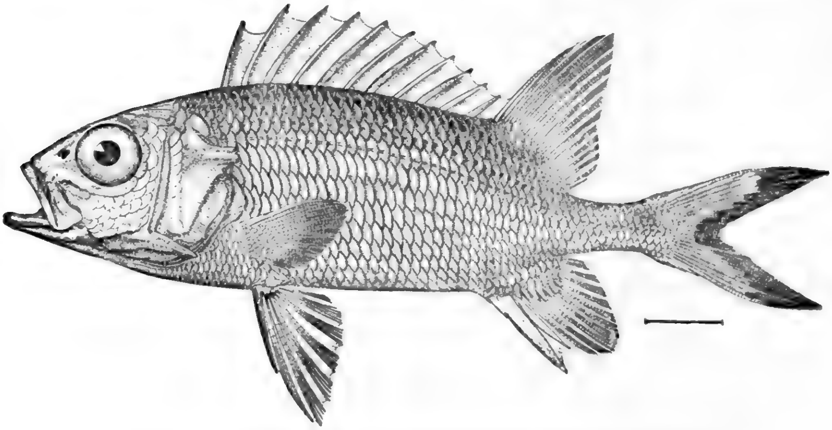


Fig. 202.—Soldier-fish, *Holocentrus ascenscionis* (Osbeck).

suborbitalis, the mojarra cardenal, is a small, relatively dull species swarming about the rocks of western Mexico. *Holo-*

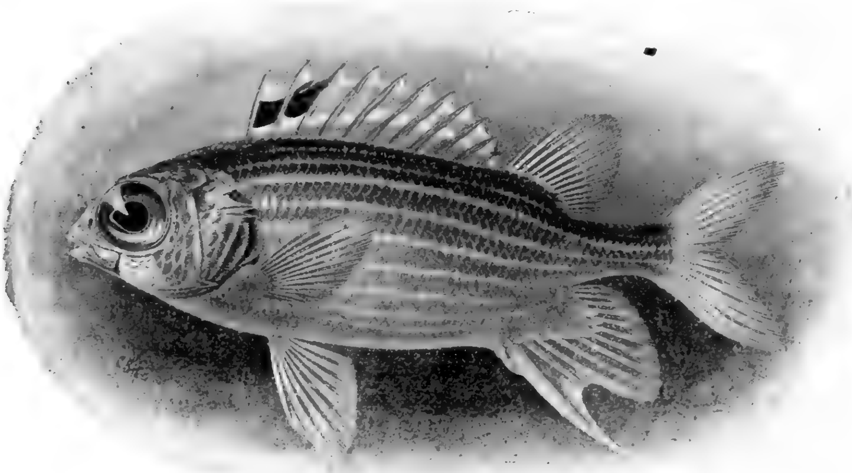


Fig. 203.—Soldier-fish, *Holocentrus ittodai* Jordan & Fowler. Riu Kiu Islands, Japan.

centrus spinosissimus is a characteristic fish of Japan. Many other species abound throughout Polynesia and the East Indies, as well as in tropical America. *Holocentrus ruber* and *Holo-*

centrus diadema are common species of Polynesia and the East Indies. Other abundant species are *H. spinifer*, *H. microstomus*, and *H. violascens*.

Holocentrus marianus is the marian of the French West Indies. *Holocentrus sammara*, and related large-mouthed species occur in Polynesia.

In *Myripristis* the preopercular spine is wanting and the air-bladder is divided into two parts, the anterior extending to the ear. *Myripristis jacobus* is the brilliantly colored candil,

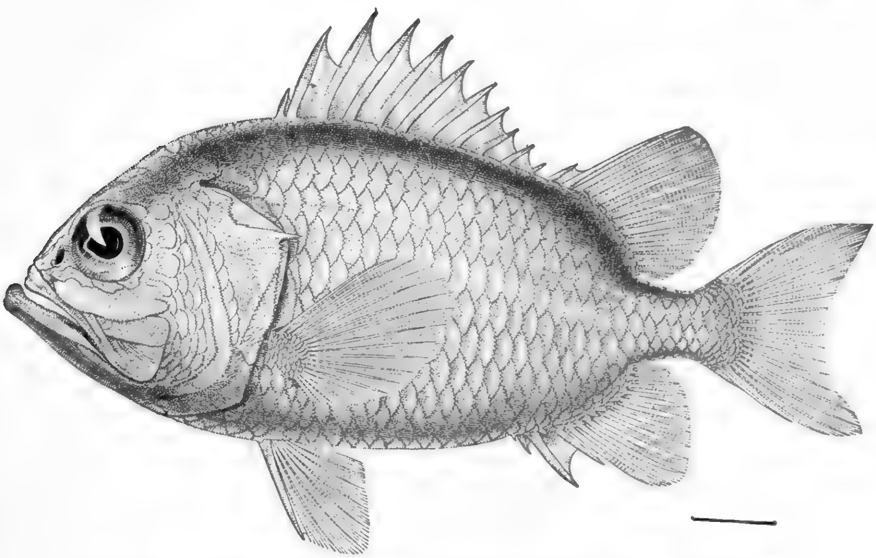


FIG. 204.—*Ostichthys japonicus* (Cuv. & Val.). Giran, Formosa.

or "Frère Jacques," of the West Indies. Species of *Myripristis* are known in Hawaii as *u-u*. A curious method of catching *Myripristis murdjan* is pursued on the Island of Hawaii. A living fish is suspended by a cord in front of a reef inhabited by this species. It remains with scarlet fins spread and glistening red scales. Its presence is a challenge to other individuals, who rush out to attack it. These are then drawn out by a concealed scoop-net, and a fresh specimen is taken as a decoy. *Myripristis pralinius*, *M. multiradiatus*, and other species occur in Polynesia. *Ostichthys* is allied to *Myripristis* but with very large rough scales. *Ostichthys japonicus* is a large and showy fish of the waters of Japan. *Ostichthys pillwaxi*

occurs at Honolulu. *Holotrachys lima* is a small, brick-red fish with small very rough scales found throughout Polynesia.

Fossil species of *Holocentrus*, *Myripristis*, and related extinct genera occur in the Eocene and Miocene. *Holocentrus macrocephalus*, from Monte Bolca Eocene, is one of the best known. *Myricanthus leptacanthus* from the same region, has very slender spines in the fins.

The Polymixiidæ.—The family of *Polymixiidæ*, or barbudos, is one of the most interesting in Ichthyology from its bewildering combination of characters belonging to different groups. With the general aspect of a Berycoid, the ventral rays I, 7,

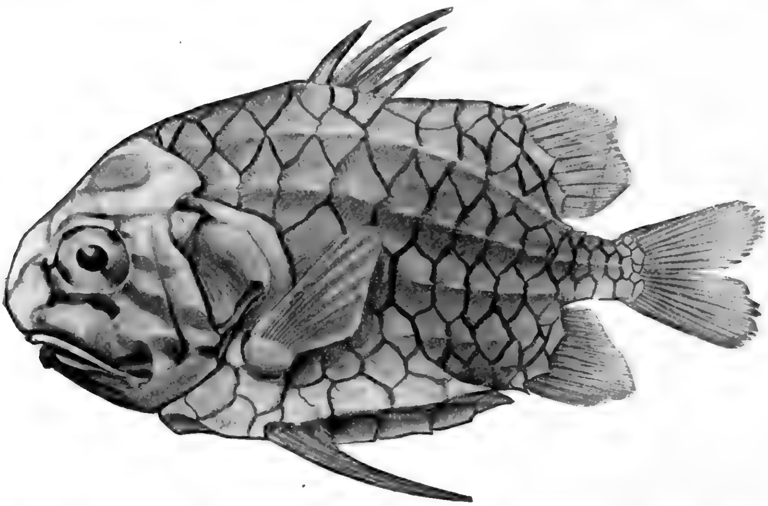


FIG. 205.—Pine-cone Fish, *Monocentris japonicus* (Houttuyn). Waka, Japan.

and the single dorsal fin with a few spines, *Polymixia* has the scales rather smooth and at the chin are two long barbels which look remarkably like those of the family of *Mullidæ* or *Surmullets*. As in the *Mullidæ*, there are but four branchiostegals. In other regards the two groups seem to have little in common. According to Starks, the specialized feelers at the chin are different in structure and must have been independently developed in the two groups. In *Polymixia*, each barbel is suspended from the hypohyal; three rudimentary branchiostegals forming its thickened base. In *Mullus*, each barbel is suspended from the trip of a slender projection of the ceratohyal, having no connection with the branchiostegals. *Polymixia* pos-

sesses the orbitosphenoid bone and is a true berycoid, while the *Mullidæ* are genuine percoid fishes.

Four species of *Polymixia* are recorded from rather deep water: *Polymixia nobilis* from Madeira, *Polymixia lowei* from the West Indies, *Polymixia berndti* from Hawaii, and *Polymixia japonica* from Japan. All are plainly colored, without red.

The Pine-cone Fishes: Monocentridæ.—Among the most extraordinary of all fishes is the little family of *Monocentridæ*, or pine-cone fishes. *Monocentris japonicus*, the best-known species, is common on the coasts of Japan. It reaches the length of five inches. The body is covered with a coat of mail, made of rough plates which look as though carelessly put together. The dorsal spines are very strong, and each ventral fin is replaced by a very strong rough spine. The animal fully justifies the remark of its discoverer, Houttuyn (1782), that it is "the most remarkable fish which exists." It is dull golden brown in color, and in movement as sluggish as a trunkfish. A similar species, called knightfish, *Monocentris gloriæ-maris*, is found in Australia. No fossils allied to *Monocentris* are known.

CHAPTER XVI

PERCOMORPHI

SUBORDER Percomorphi, the Mackerels and Perches.—We may place in a single suborder the various groups of fishes which cluster about the perches, and the mackerels. The group is not easily definable and may contain heterogeneous elements. We may, however, arrange in it, for our present purposes, those spiny-rayed fishes having the ventral fins thoracic, of one spine and five rays (the ventral fin occasionally wanting or defective, having a reduced number of rays), the lower pharyngeal bones separate, the suborbital chain without backward extension or bony stay, the post-temporal normally developed and separate from the cranium, the premaxillary and maxillary distinct, the cranium itself without orbitosphenoid bone, having a structure not greatly unlike that of perch or mackerel, and the backbone primitively of twenty-four vertebræ, the number increased in arctic, pelagic, or fresh-water offshoots.

The species, comprising the great body of the spiny-rayed forms, group themselves chiefly about two central families, the *Scombridæ*, or mackerels, and the *Serranidæ*, the sea-bass, with their fresh-water allies, the *Percidæ*, or perch.

The Mackerel Tribe: Scombroidea.—The two groups of *Percomorphi*, the mackerel-like and the perch-like, admit of no exact definition, as the one fully grades into the other. The mackerel-like forms, or *Scombroidea*, as a whole are defined by their adaptation for swift movement. The profile is sharp anteriorly, the tail slender, with widely forked caudal; the scales are usually small, thin, and smooth, of such a character as not to produce friction in the water.

In general the external surface is smooth, the skeleton light and strong, the muscles firm, and the species are carniv-

orous and predaceous. But among the multitude of forms are many variations, and some of these will seem to be exceptions to any definition of mackerel-like fishes which could possibly be framed.

The mackerels, or *Scombroidea*, have usually the tail very slender, composed of very strong bones, with widely forked fin. In the perch and bass the tail is stout, composed largely of flesh, the supporting vertebræ relatively small and spread out fan-fashion behind. Neither mackerels nor perch nor any of their near allies ever have more than five soft rays in the ventral fins, and the persistence of this number throughout the *Percomorphi*, *Squamipinnes*, *Pharyngognathi*, and spiny fishes generally must be attributed to inheritance from the primitive perch-like or mackerel-like forms. In almost all the groups to be considered in this work, after the *Berycoidea* the ventral rays are I, 5, or else fewer through degeneration, never more. In the central or primitive members of most of these groups there are twenty-four vertebræ, the number increased in certain forms, probably through repetitive degeneration.

The True Mackerels: Scombridæ.—We may first consider the great central family of *Scombridæ*, or true mackerels, distinguished among related families by their swift forms, smooth scales, metallic coloration, and technically by the presence of a number of detached finlets behind the dorsal and anal fins. The cut of the mouth is peculiar, the spines in the fins are feeble, the muscular system is extremely strong, the flesh oily, and the air-bladder reduced in size or altogether wanting. As in most swift-swimming fishes and fishes of pelagic habit, the vertebræ are numerous and relatively small, an arrangement which promotes flexibility of body. It is not likely that this group is the most primitive of the scombroid fishes. In some respects the *Stromateidæ* stand nearer the primitive stock. The true mackerels, however, furnish the most convenient point of departure in reviewing the great group.

In the genus of true mackerels, *Scomber*, the dorsal fins are well separated, the first being rather short, and the scales of the shoulders are not modified to form a corselet. There are numerous species, two of them of general interest. The

common mackerel, *Scomber scombrus*, is one of the best known of food-fishes. It is probably confined to the Atlantic, where on both shores it runs in vast schools, the movements varying greatly from season to season, the preference being for cool waters. The female mackerel produces about 500,000 eggs each year, according to Professor Goode. These are very minute and each is provided with an oil-globule, which causes it to float on the surface. About 400,000 barrels of mackerel are salted yearly by the mackerel fleet of Massachusetts. Single schools of mackerel, estimated to contain a million barrels, have been recorded. Captain Harding describes such a school

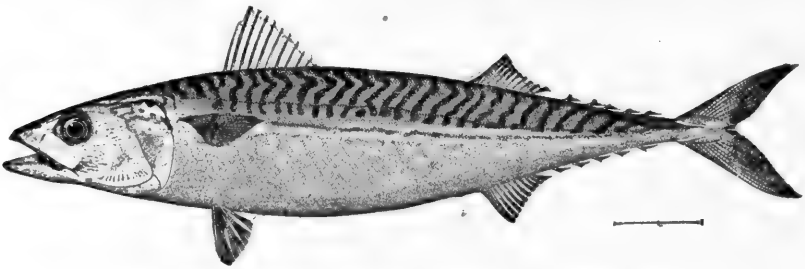


FIG. 206.—Mackerel, *Scomber scombrus* L. New York.

as "a windrow of fish half a mile wide and twenty miles long."

Professor Goode writes:

"Upon the abundance of mackerel depends the welfare of many thousands of the citizens of Massachusetts and Maine. The success of the mackerel-fishery is much more uncertain than that of the cod-fishery, for instance, for the supply of cod is quite uniform from year to year. The prospects of each season are eagerly discussed from week to week in thousands of little circles along the coast, and are chronicled by the local press. The story of each successful trip is passed from mouth to mouth, and is a matter of general congratulation in each fishing community. A review of the results of the American mackerel-fishery, and of the movements of the fish in each part of the season, would be an important contribution to the literature of the American fisheries.

"The mackerel-fishery is peculiarly American, and its history is full of romance. There are no finer vessels afloat than the

American mackerel-schooners—yachts of great speed and unsurpassed for seaworthiness. The modern instruments of capture are marvels of inventive skill, and require the highest degree of energy and intelligence on the part of the fishermen. The crews of the mackerel-schooners are still for the most part Americans of the old colonial stock, although the cod and halibut fisheries are to a great extent given up to foreigners.

"When the mackerel is caught, trout, bass, and sheepshead cannot vanquish him in a gastronomic tournament. In Holland, to be sure, the mackerel is not prized, and is accused of tasting like rancid fish-oil, and in England, even, they are usually lean and dry, like the wretched skeletons which are brought to market in April and May by the southern fleet, which goes forth in the early spring from Massachusetts to intercept the schools as they approach the coasts of Carolina and Virginia. They are not worthy of the name of mackerel. *Scomber Scombrus* is not properly in season until the spawning time is over, when the schools begin to feed at the surface in the Gulf of Maine and the 'North Bay.'

"Just from the water, fat enough to broil in its own drippings, or slightly corned in strong brine, caught at night and eaten in the morning, a mackerel or a bluefish is unsurpassable. A well-cured autumn mackerel is perhaps the finest of all salted fish, but in these days of wholesale capture by the purse-seine, hasty dressing and careless handling, it is very difficult to obtain a sweet and sound salt mackerel. Salt mackerel may be boiled as well as broiled, and a fresh mackerel may be cooked in the same manner. Americans will usually prefer to do without the sauce of fennel and gooseberry which transatlantic cooks recommend. Fresh and salt, fat and lean, new or stale, mackerel are consumed by Americans in immense quantities, as the statistics show, and whatever their state, always find ready sale."

Smaller, less important, less useful, but far more widely distributed is the chub-mackerel, or thimble-eyed mackerel, *Scomber japonicus* (Houttuyn, 1782), usually known by the later name of *Scomber colias* (Gmelin, 1788). In this species the air-bladder (absent in the common mackerel) is moder-

ately developed. It very much resembles the true mackerel, but is of smaller size, less excellence as a food-fish, and keeps nearer to the shore. It may be usually distinguished by the presence of vague, dull-gray spots on the sides, where the true mackerel is lustrous silvery.

This fish is common in the Mediterranean, along our Atlantic coast, on the coast of California, and everywhere in Japan.

Scomber antarcticus is the familiar mackerel of Australia. *Scomber loo*, silvery, with round black spots, is the common mackerel of the South Seas, locally known as *Ga*.

Scomber priscus is a fossil mackerel from the Eocene.

Auxis thazard, the frigate mackerel, has the scales of the shoulders enlarged and somewhat coalescent, forming what is called a corselet. The species ranges widely through the seas of the world in great numbers, but very erratic, sometimes myriads reaching our Eastern coast, then none seen for years. It is more constant in its visits to Japan and Hawaii. Fossil species of *Auxis* are found in the Miocene.

The genus *Gymnosarda* has the corselet as in *Auxis*, but the first dorsal fin is long, extending backward to the base of the second. Its two species, *Gymnosarda pelamis*, the Oceanic bonito, and *Gymnosarda alleterata*, the little tunny, are found in all warm seas, being especially abundant in the Mediterranean, about Hawaii and Japan. These are plump fish of moderate size, with very red and very oily flesh.

Closely related to these is the great tunny, or Tuna (*Thunnus thynnus*) found in all warm seas and reaching at times a weight of 1500 pounds. These enormous fishes are much valued by anglers, a popular "Tuna Club" devoted to the sport of catching them with a hook having its headquarters at Avalon, on Santa Catalina Island in California. They are good food, although the flesh of the large ones is very oily. The name horse-mackerel is often given to these monsters on the New England coast. In California, the Spanish name of tuna has become current among fisherman.

Very similar to the tuna, but much smaller, is the Albacore (*Germo alalonga*). This reaches a weight of fifteen to thirty pounds, and is known by its very long, almost ribbon-like pectoral fins. This species is common in the Mediterranean, and

about the Santa Barbara Islands, where it runs in great schools in March. The flesh of the albacore is of little value, unless, as in Japan, it is eaten raw. The Japanese shibi (*Germo germo*) is another large albacore, having the finlets bright yellow. It is found also at Hawaii.

The bonito (*Sarda sarda*) wanders far throughout the Atlantic, abounding on our Atlantic coast as in the Mediterranean, coming inshore in summer to spawn or feed. Its flesh is red and not very delicate, though it may be reckoned as a fair food-

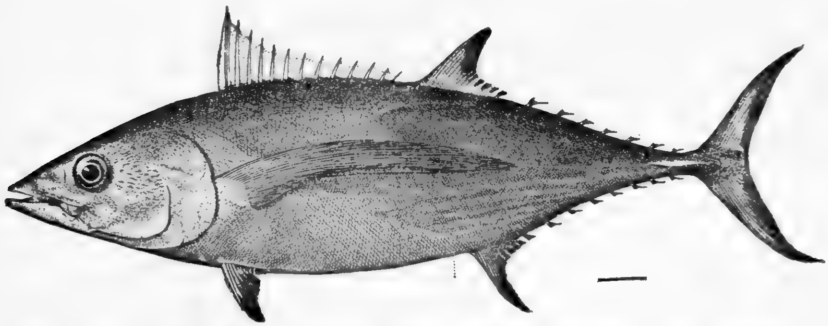


FIG. 207.—The Long-fin Albacore, *Germo alalunga* (Gmelin). Gulf Stream.

fish. It is often served under the name of "Spanish mackerel" to the injury of the reputation of the better fish.

Professor Goode writes:

"One of these fishes is a marvel of beauty and strength. Every line in its contour is suggestive of swift motion. The head is shaped like a minie bullet, the jaws fit together so tightly that a knife-edge could scarcely pass between, the eyes are hard, smooth, their surfaces on a perfect level with the adjoining surfaces. The shoulders are heavy and strong, the contours of the powerful masses of muscle gently and evenly merging into the straighter lines in which the contour of the body slopes back to the tail. The dorsal fin is placed in a groove into which it is received, like the blade of a clasp-knife in its handle. The pectoral and ventral fins also fit into depressions in the sides of the fish. Above and below, on the posterior third of the body, are placed the little finlets, each a little rudder with independent motions of its own, by which the course of the fish may be readily steered. The tail itself is a

crescent-shaped oar, without flesh, almost without scales, composed of bundles of rays flexible, yet almost as hard as ivory. A single sweep of this powerful oar doubtless suffices to propel the bonito a hundred yards, for the polished surfaces of its body can offer little resistance to the water. I have seen a common dolphin swimming round and round a steamship, advancing at the rate of twelve knots an hour, the effort being hardly perceptible. The wild duck is said to fly seventy miles in an hour. Who can calculate the speed of the bonito? It might be done by the aid of the electrical contrivances by which is calculated the initial velocity of a projectile. The bonitoes in our sounds to-day may have been passing Cape Colony or the Land of Fire day before yesterday."

Another bonito, *Sarda chilensis*, is common in California; in Chile, and in Japan. This species has fewer dorsal spines than the bonito of the Atlantic, but the same size, coloration, and flesh. Both are blue, with undulating black stripes along the side of the back.

The genus *Scomberomorus* includes mackerels slenderer in form, with larger teeth, no corselet, and the flesh comparatively pale and free from oil.

Scomberomorus maculatus, the Spanish mackerel of the West Indies, is one of the noblest of food-fishes. Its biography

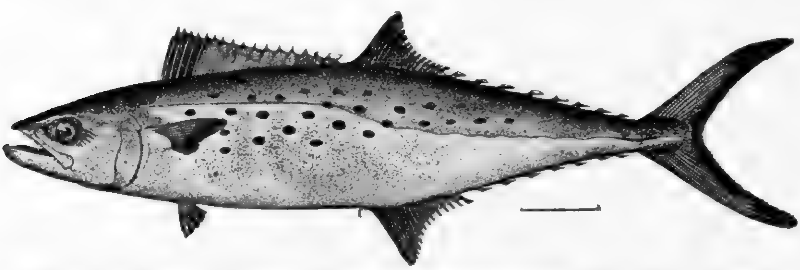


FIG. 208.—The Spanish Mackerel, *Scomberomorus maculatus* (Mitchill). New York.

was written by Mitchill almost a century ago in these words:

"A fine and beautiful fish; comes in July."

Goode thus writes of it:

"The Spanish mackerel is surely one of the most graceful

of fishes. It appeals as scarcely any other can to our love of beauty, when we look upon it, as shown in Kilbourn's well-known painting, darting like an arrow just shot from the bow, its burnished sides, silver flecked with gold, thrown into bold relief by the cool green background of the rippled sea; the transparent grays, opalescent whites, and glossy blacks of its trembling fins enhance the metallic splendor of its body, until it seems to rival the most brilliant of tropical birds. Kilbourn made copies of his large painting on the pearly linings of sea-shells and produced some wonderful effects by allowing the natural luster of the mother-of-pearl to show through his transparent pigments and simulate the brilliancy of the life-inspired hues of the quivering, darting sea-sprite, whose charms even his potent brush could not properly depict.

"It is a lover of the sun, a fish of tropical nature, which comes to us only in midsummer, and which disappears with the approach of cold, to some region not yet explored by ichthyologists. It is doubtless very familiar in winter to the inhabitants of some region adjacent to the waters of the Caribbean or the tropical Atlantic, but until this place shall have been discovered it is more satisfactory to suppose that with the bluefish and the mackerel it inhabits that hypothetical winter resort to which we send the migratory fishes whose habits we do not understand—the middle strata of the ocean, the floating beds of Sargassum, which drift hither and thither under the alternate promptings of the Gulf-stream currents and the winter winds."

The Spanish mackerel swims at the surface in moderate schools and is caught in abundance from Cape May southward. Its white flesh is most delicious, when properly grilled, and Spanish mackerel, like pampano, should be cooked in no other way.

A very similar species, *Scomberomorus sierra*, occurs on the west coast of Mexico. For some reason it is little valued as food by the Mexicans. In California, the Monterey Spanish mackerel (*Scomberomorus concolor*) is equally excellent as a food-fish. This fish lacks the spots characteristic of most of its relatives. It was first found in the Bay of Monterey, especially at Santa Cruz and Soquel, in abundance in the autumn

of 1879 and 1880. It has not, so far as is known, been seen since, nor is the species recorded from any other coast.

The true Spanish mackerel has round, bronze-black spots upon its sides. Almost exactly like it in appearance is the pintado, or sierra (*Scomberomorus regalis*), but in this species the spots are oblong in form. The pintado abounds in the West Indies. Its flesh is less delicate than that of the more true Spanish mackerel. The name *sierra*, saw, commonly applied to these fishes by Spanish-speaking people, has been corrupted into *cero* in some books on angling.

Still other Spanish mackerel of several species occur on the coasts of India, Chile, and Japan.

The great kingfish, or cavalla (*Scomberomorus cavalla*), is a huge Spanish mackerel of Cuba and the West Indies, reaching a weight of 100 pounds. It is dark iron-gray in color, one of the best of food-fishes, and is unspotted, and its firm, rich flesh resembles that of the barracuda.

Still larger is the great guahu, or peto, an immense sharp-nosed, swift-swimming mackerel found in the East and West Indies, as well as in Polynesia, reaching a length of six feet and a weight of more than a hundred pounds. Its large knife-like teeth are serrated on the edge and the color is almost black. *Acanthocybium solandri* is the species found in Hawaii and Japan. The American *Acanthocybium petus*, occasionally also taken in the Mediterranean, may be the same species.

Fossil Spanish mackerels, tunnies, and albacores, as well as representatives of related genera now extinct, abound in the Eocene and Miocene, especially in northern Italy. Among them are *Scomber antiquus* from the Miocene, *Scombrinus macropomus* from the Eocene London clays, much like *Scomber*, but with stronger teeth, *Sphyrænodus priscus* from the same deposits, the teeth still larger, *Scombramphodon crossidens*, from the same deposits, also with strong teeth, like those of *Scomberomorus*. *Scomberomorus* is the best represented of all the genera as fossil, *Scomberomorus speciosus* and numerous other species occurring in the Eocene. A fossil species of *Germo*, *G. lanceolatus*, occurs at Monte Bolca in Eocene rocks. Another tunny, with very small teeth is *Eothynnus salmonens*,

from the lower Eocene near London. Several other tunny-like fishes occur in the lower Tertiary.

The Escolars: Gempylidæ.—More predaceous than the mackerels and tunnies are the pelagic mackerels, *Gempylidæ*, known as *escolars* ("scholars"), with the body almost band-shaped and the teeth very large and sharp. Some of these, from the ocean depths, are violet-black in color, those near the surface being silvery. *Escolar violaceus* lives in the abysses of the Gulf Stream. *Ruvettus pretiosus*, the black escolar, lives in more moderate depths and is often taken in Cuba, Madeira, Hawaii, and Japan. It is a very large fish, black, with very rough scales. The flesh is white, soft, and full of oil; sometimes rated very high, and at other times too rank to be edible. The name *escolar* means *scholar* in Spanish, but its root meaning, as applied to this fish, comes from a word meaning *to scour*, in allusion to the very rough scales.

Promethichthys prometheus, the rabbit-fish, or conejo, so-called from its wariness, is caught in the same regions, being especially common about Madeira and Hawaii. *Gempylus serpens*, the snake-mackerel, is a still slenderer and more voracious fish of the open seas. *Thyrsites atun* is the Australian "barracuda," a valued food-fish, voracious and predaceous.

Scabbard- and Cutlass-fishes: Lepidopidæ and Trichiuridæ.—The family of *Lepidopidæ*, or scabbard-fishes, includes degenerate mackerels, band-shaped, with continuous dorsal fin, and the long jaws armed with very small teeth. These are found in the open sea, *Lepidopus candatus* being the most common. This species reaches a length of five or six feet and comes to different coasts occasionally to deposit its spawn. It lives in warm water and is at once chilled by the least cold; hence the name of frostfish occasionally applied to it. Several species of *Lepidopus* are fossil in the later Tertiary. *Lepidopus glarisianus* occurs in the Swiss Oligocene, and with it *Thyrsitocephalus alpinus*, which approaches more nearly to the *Gempylidæ*.

Still more degenerate are the *Trichiuridæ*, or cutlass-fishes, in which the caudal fin is wanting, the tail ending in a hair-like filament. The species are bright silvery in color, very slender, and very voracious, reaching a length of three to five feet.

Trichiurus lepturus is rather common on our Atlantic coast. The names hairfish and silver-eel, among others, are often given to it. *Trichiurus japonicus*, a very similar species, is common

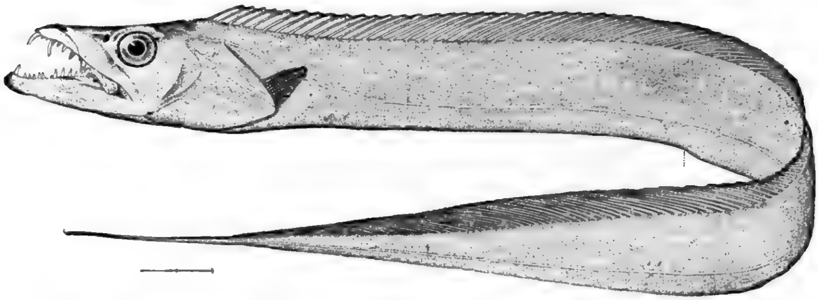


Fig. 209.—Cutlass-fish, *Trichiurus lepturus* Linnæus. St. Augustine, Fla.

in Japan, and other species inhabit the tropical seas. *Trichiurichthys*, a fossil genus with well-developed scales, precedes *Trichiurus* in the Miocene.

The Palæorhynchidæ.—The extinct family of *Palæorhynchidæ* is found from the Eocene to the Oligocene. It contains very

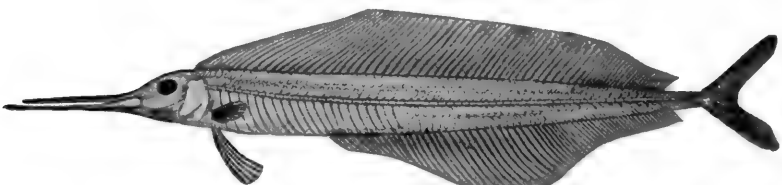


Fig. 210.—*Palæorhynchus glarisianus* Blainville. Oligocene. (After Woodward.)

long and slender fishes, with long jaws and small teeth, the dorsal fin long and continuous. The species resembles the *Escolar* on the one hand and the sailfishes on the other, and they may prove to be ancestral to the *Istiophoridæ*. *Hemirhynchus deshayesi* with the upper jaw twice as long as the lower, sword-like, occurs in the Eocene at Paris; *Palæorhynchum glarisianum*, with the jaws both elongate, the lower longest, is in the Oligocene of Glarus. Several other species of both genera are recorded.

The Sailfishes: Istiophoridæ.—Remotely allied to the cutlass-fishes and still nearer to the *Palæorhynchidæ* is the family of sailfishes, *Istiophoridæ*, having the upper jaw prolonged into

a sword made of consolidated bones. The teeth are very feeble and the ventral fins reduced to two or three rays. The species are few in number, of large size, and very brilliant metallic coloration, inhabiting the warm seas, moving northward in summer. They are excellent as food, similar to the swordfish in this as in many other respects. The species are not well known, being too large for museum purposes, and no one having critically studied them in the field. *Istiophorus* has the dorsal fin very high, like a great sail, and undivided; *Istiophorus nigricans* is rather common about the Florida Keys, where it reaches a length of six feet. Its great sail, blue with black spots, is a very striking object. Closely related to this is *Istiophorus orientalis* of Japan and other less known species of the East Indies.

Tetrapturus, the spearfish, has the dorsal fin low and divided into two parts. Its species are taken in most warm seas, *Tetrapturus imperator* throughout the Atlantic, *Tetrapturus amplus* in Cuba, *Tetrapturus mitsukurii* and *Tetrapturus mazara* in Japan. These much resemble swordfish in form and habits, and they have been known to strike boats in the same way.

Fossil *Istiophoridæ* are known only from fragments of the snout, in Europe and America, referred provisionally to *Istiophorus*. The genus *Xiphiorhynchus*, fossil swordfishes from the Eocene, known from the skull only, may be referred to this family, as minute teeth are present in the jaws. *Xiphiorhynchus priscus* is found in the London Eocene.

The Swordfishes: Xiphiidæ. — The family of swordfishes, *Xiphiidæ*, consists of a single species, *Xiphias gladius*, of world-

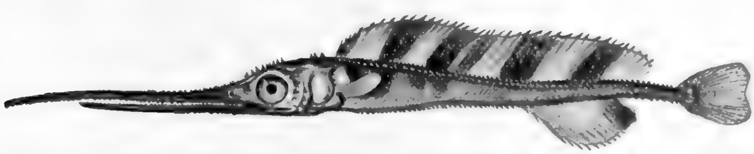


Fig. 211.—Young Swordfish, *Xiphias gladius* (Linnæus). (After Lutken.)

wide distribution in the warm seas. The snout in the swordfish is still longer, more perfectly consolidated, and a still more effective weapon of attack. The teeth are wholly wanting, and there are no ventral fins, while the second of the two fins on the back is reduced to a slight finlet.

The swordfish follows the schools of mackerel to the New England coasts. "Where you see swordfish, you may know that mackerel are about," Goode quotes from an old fisherman. The swordfish swims near the surface, allowing its dorsal fin to appear, as also the upper lobe of the caudal. It often leaps out of the water, and none of all the fishes of the sea can swim more swiftly.

"The pointed head," says Goode, "the fins of the back and abdomen snugly fitting into grooves, the absence of ventrals, the long, lithe, muscular body, sloping slowly to the tail, fit

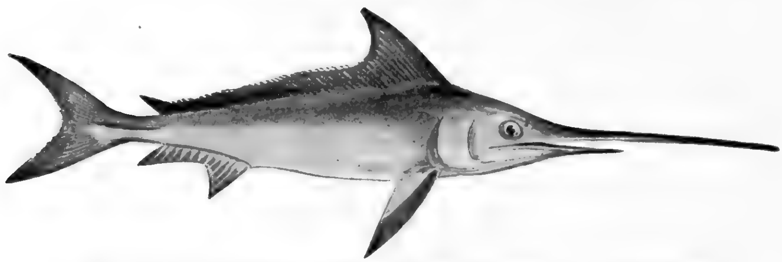


FIG. 212.—Swordfish, *Xiphias gladius* (Linnæus). (After Day.)

it for the most rapid and forcible movement through the water. Prof. Richard Owen, testifying in an England court in regard to its power, said:

"'It strikes with the accumulated force of fifteen double-handed hammers. Its velocity is equal to that of a swivel-shot, and is as dangerous in its effects as a heavy artillery projectile.'

"Many very curious instances are on record of the encounters of this fish with other fishes, or of their attacks upon ships. What can be the inducement for it to attack objects so much larger than itself it is hard to surmise.

"It surely seems as if a temporary insanity sometimes takes possession of the fish. It is not strange that, when harpooned, it should retaliate by attacking its assailant. An old swordfish fisherman told Mr. Blackford that his vessel had been struck twenty times. There are, however, many instances of entirely unprovoked assault on vessels at sea. Many of these are recounted in a later portion of this memoir. Their movements when feeding are discussed below, as well as their alleged peculiarities of movement during the breeding season.

"It is the universal testimony of our fishermen that two are never seen swimming close together. Capt. Ashby says that they are always distant from each other at least thirty or forty feet.

"The pugnacity of the swordfish has become a byword. Without any special effort on my part numerous instances of their attacks upon vessels have in the last ten years found their way into the pigeon-hole labeled 'Swordfish.'"

Swordfishes are common on both shores of the Atlantic wherever mackerel run. They do not breed on our shores, but probably do so in the Mediterranean and other warm seas. They are rare off the California coast, but five records existing (Anacapa, Santa Barbara, Santa Catalina, San Diego, off Cerros Island). The writer has seen two large individuals in the market of Yokohama, but it is scarcely known in Japan. As a food-fish, the swordfish is one of the best, its dark-colored oily flesh, though a little coarse, making most excellent steaks. Its average weight on our coast is about 300 pounds, the maximum 625.

The swordfish undergoes great change in the process of development, the very young having the head armed with rough spines and in nowise resembling the adult.

Fossil swordfishes are unknown, or perhaps cannot be distinguished from remains of *Istiophoridæ*.

CHAPTER XVII

CAVALLAS AND PAMPANOS

THE **Pampanos: Carangidæ.**—We next take up the great family of Pampanos, *Carangidæ*, distinguished from the *Scombridæ* as a whole by the shorter, deeper body, the fewer and larger vertebræ, and by the loss of the provision for swift movement in the open sea characteristic of the mackerels and their immediate allies. A simple mark of the *Carangidæ* is the presence of two separate spines in front of the anal fin. These spines are joined to the fin in the young. All of the species undergo considerable changes with age, and almost all are silvery in color with metallic blue on the back.

Most like the true mackerel are the "leather-jackets," or "runners," forming the genera *Scomberoides* and *Oligoplites*. *Scomberoides* of the Old World has the body scaly, long, slender, and fitted for swift motion; *Scomberoides sancti-petri* is a widely diffused species, and others are found in Polynesia. In the New World genus *Oligoplites* the scales are reduced to linear ridges imbedded in the skin at different angles. *Oligoplites saurus* is a common dry and bony fish abounding in the West Indies and ranging north in summer to Cape Cod.

Naucrates ductor, the pilotfish, or romero, inhabits the open sea, being taken—everywhere rarely—in Europe, the West Indies, Hawaii, and Japan. It is marked by six black cross-bands. Its tail has a keel, and it reaches a length of about two feet. In its development it undergoes considerable change, its first dorsal fin being finally reduced to disconnected spines.

The amber-fishes, forming the genus *Seriola*, are rather robust fishes, with the anal fin much shorter than the soft dorsal. The sides of the tail have a low, smooth keel. From a yellow streak obliquely across the head in some species they receive their Spanish name of coronado. The species are

numerous, found in all warm seas, of fair quality as food, and range in length from two to six feet.

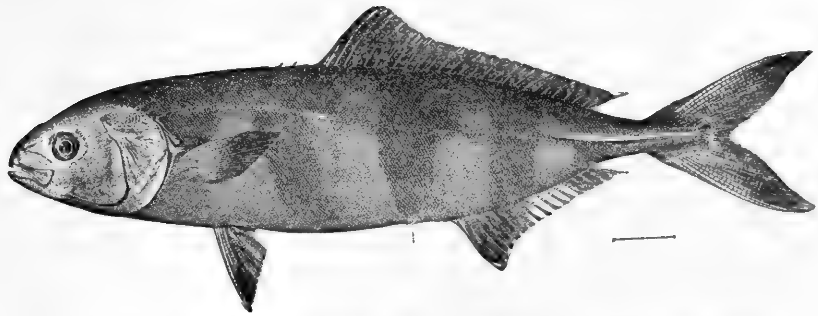


FIG. 213.—Pilot-fish, *Naucrates ductor* (Linnæus). New Bedford, Mass.

Seriola dorsalis is the noted yellow-tail of California, valued by anglers for its game qualities. It comes to the Santa Bar-

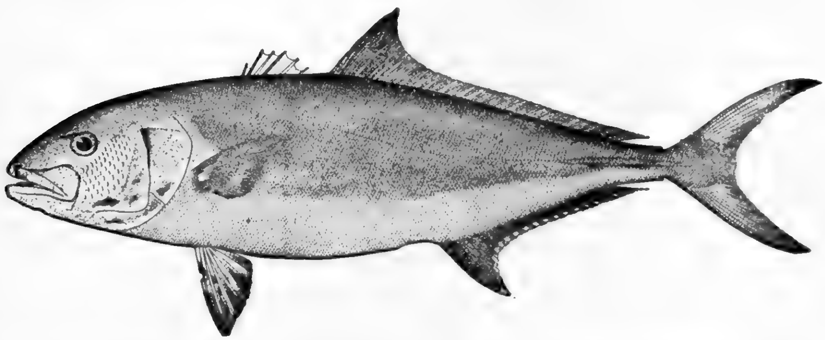


FIG. 214.—Amber-fish, *Seriola lalandi* (Cuv. & Val.). Family *Carangidæ*. Wood's Hole.

bara Islands in early summer. *Seriola zonata* is the rudder-fish, or shark's pilot, common on our New England coast. The banded young, abundant off Cape Cod, lose their marks with age. *Seriola hippos* is the "samson-fish" of Australia. *Seriola lalandi* is the great amber-fish of the West Indies, occasionally venturing farther northward, and *Seriola dumerili* the amber-jack, or coronado, of the Mediterranean. The deep-bodied medregal (*Seriola fasciata*) is also taken in the West Indies, as is also the high-finned *Seriola rivoliana*. Species very similar to these occur in Hawaii and Japan, where they

are known as *Ao*, or bluefishes. *Seriola lata* is fossil in the mountains of Tuscany.

The runner, *Elegatis bipinnulatus*, differs from *Seriola* in having a finlet behind dorsal and anal. It is found in almost all warm seas, ranging north once in a while to Long Island.

The mackerel scads (*Decapterus*) have also a finlet, and on the posterior part of the body the lateral line is shielded with bony plates. In size and form these little fishes much resemble small mackerel, and they are much valued as food wherever abundant. *Decapterus punclatus*, known also as cigar-fish and round-robin, frequently visits our Atlantic coasts from the West Indies, where it is abundant. *Decapterus russelli* is the *Maru-aji*, highly valued in Japan for its abundance, while *Decapterus muroadsi* is the Japanese muroaji.

Megalaspis cordyla abounds in the East Indies and Poly-

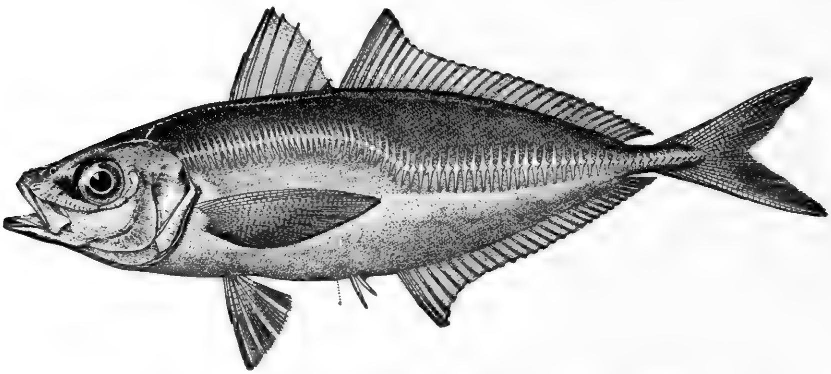


FIG. 215.—The Saurel, *Trachurus trachurus* (Linnæus). Newport, R. I.

nesia. It has many finlets, and the bony plates on the lateral line are developed to an extraordinary degree.

In *Trachurus* the finlets are lost and the bony plates extend the whole length of the lateral line. The species known as saurel and wrongly called horse-mackerel are closely related and some of them very widely distributed.

Trachurus trachurus common in Europe, extends to Japan where it is the abundant maaji. *Trachurus mediterraneus* is common in southern Europe and *Trachurus symmetricus* in California. *Trachurus picturatus* of Madeira is much the same

as the last named, and there is much question as to the right names and proper limits of all these species.

In *Trachurops* the bony plates are lacking on the anterior half of the body, and there is a peculiar nick and projection on the lower part of the anterior edge of the shoulder-girdle. *Trachurops crumenophthalma*, the goggler, or big-eyed scad, ranges widely in the open sea and at Hawaii, as the *Akule*, is the most highly valued because most abundant of the migratory fishes. At Samoa it is equally abundant, the name being here *Atule*. *Trachurops torva* is the meaji, or big-eyed scad, of the Japanese, always abundant.

To *Caranx*, *Carangus*, and a number of related genera, characterized by the bony armature on the narrow caudal peduncle, a host of species may be referred. These fishes, known as cavallas,

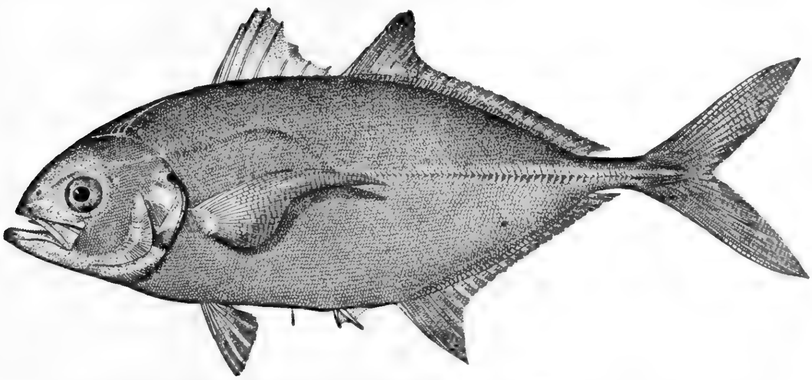


Fig. 216.—Yellow Mackerel, *Carangus chrysos* (Mitchill). Wood's Hole.

hard-tails, jacks, etc., are broad-bodied, silvery or metallic black in color, and are found in all warm seas. They usually move from the tropics northward in the fall in search of food and are especially abundant on our Atlantic coast, in Polynesia, and in Japan. About the Oceanic Islands they are resident, these being their chosen spawning-grounds. In Hawaii and Samoa they form a large part of the food-supply, the ulua (*Carangus forsteri*) and the malauli (*Carangus melampygus*) being among the most valuable food-fishes, large in size and excellent in flesh, unsurpassed in fish chowders. Of the American species *Carangus chrysos*, called yellow mackerel, is the most abundant, ranging from Cape

Cod southward. This is an elongate species of moderate size. The cavalla, or jiguagua, *Carangus hippos*, known by the black spot on the opercle, with another on the pectoral fin, is a widely distributed species and one of the largest of the tribe. Another important food-fish is the horse-eye-jack, or jurel, *Carangus latus*, which is very similar to the species called ulua in the Pacific. The black jack, or tiñosa, of Cuba, *Carangus funebris*, is said to be often poisonous. This is a very large species, black in color, the sale of which has been long forbidden in the markets of Havana. The young of different species of *Carangus* are often found taking refuge under the disk of jelly-fishes protected by the stinging feelers. The species of the genus *Carangus* have well-developed teeth. In the restricted genus of *Caranx* proper, the jaws are toothless. *Caranx speciosus*, golden with dark cross-bands, is a large food-fish of the Pacific. *Citula armata* is another widely distributed species, with some of the dorsal rays produced in long filaments.

In *Alectis ciliaris*, the cobbler-fish, or threadfish, the armature of the tail is very slight and each fin has some of its rays drawn out into long threads. In the young these are very much longer than the body, but with age they wear off and grow shorter, while the body becomes more elongate. In *Vomer*, *Selene*, and *Chloroscombrus* the bony armature of the tail, feeble in *Alectis*, by degrees entirely disappears.

Vomer setipinnis, the so-called moonfish, or jorobado, has the body greatly elevated, compressed, and distorted, while the fins, growing shorter with age, become finally very low. *Selene vomer*, the horse-head-fish, or look-down (see Fig. 113, Vol. I), is similarly but even more distorted. The fins, filamentous in the young, grow shorter with age, as in *Vomer* and *Alectis*. The skeleton in these fishes is essentially like that of *Carangus*, the only difference lying in the compression and distortion of the bones. *Chloroscombrus* contains the casabes, or bumpers, thin, dry, compressed fish, of little value as food, the bony armature of the tail being wholly lost.

To the genus *Trachinotus* belong the pampanos, broad-bodied, silvery fishes, toothless when adult, the bodies covered with small scales and with no bony plates.

The true pampano, *Trachinotus carolinus*, is one of the

finest of all food-fishes, ranking with the Spanish mackerel and to be cooked in the same way, only by broiling. The flesh is white, firm, and flaky, with a moderate amount of delicate oil. It has no especial interest to the angler and it is not abundant enough to be of great commercial importance, yet few fish bring or deserve to bring higher prices in the markets of the

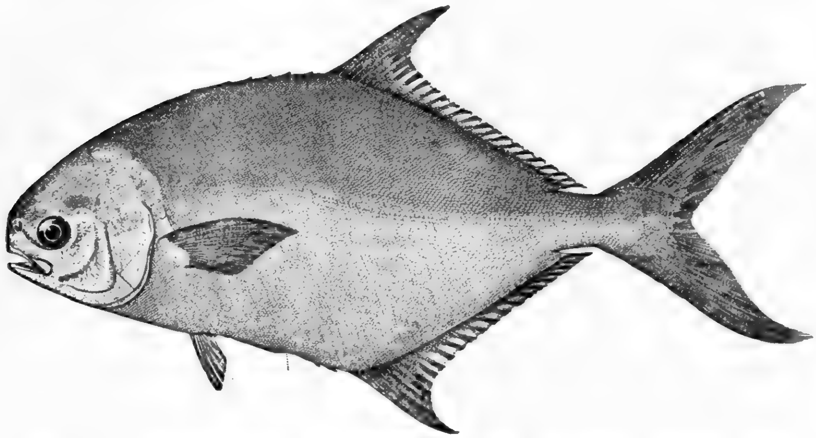


FIG. 217.—The Pampano, *Trachinotus carolinus* (Linnæus). Wood's Hole.

epicures. The species is most common along our Gulf coast, ranging northward along the Carolinas as far as Cape Cod.

Pampano in Spanish means the leaf of the grape, from the broad body of the fish. The spelling "pompano" should therefore be discouraged.

The other pampanos, of which there are several in tropical America and Asia, are little esteemed, the flesh being dry and relatively flavorless. *Trachinotus palometa*, the gafftopsail pampano, has very high fins and its sides have four black bands like the marks of a grill. The round pampano, *Trachinotus falcatus*, is common southward, as is also the great pampano, *Trachinotus goodei*, which reaches a length of three feet. *Trachinotus ovatus*, a large deep-bodied pampano, is common in Polynesia and the East Indies. No pampanos are found in Europe, but a related genus, *Lichia*, contains species which much resemble them, but in which the body is more elongate and the mouth larger.

Numerous fossils are referred to the *Carangidæ* with more

or less certainty. *Aipichthys pretiosus* and other species occur in the Cretaceous. These are deep-bodied fishes resembling *Seriola*, having the falcate dorsal twice as long as the anal and the ventral ridge with thickened scales. *Vomeropsis* (*longispina elongata*, etc.), also from the Eocene, with rounded caudal, the anterior dorsal rays greatly elongate, and the supraoccipital crest highly developed, probably constitutes with it a distinct family, *Vomeropsidæ*. Several species referable to *Carangus* are found in the Miocene. *Archæus glarisianus*, resembling *Carangus*, but without scales so far as known, is found in the Oligocene of Glarus; *Seriola prisca* and other species of *Seriola* occur in the Eocene; *Carangopsis brevis*, etc., allied to *Caranx*, but with the lateral line unarmed, is recorded from the Eocene of France and Italy.

Ductor leptosomus from the Eocene of Monte Bolca resembles *Naucrates; Trachinotus tenuiceps* is recorded from Monte Bolca, and a species of uncertain relationship, called *Pseudovomer minutus*, with sixteen caudal vertebræ is taken from the Miocene of Licata.

The Papagallos: Nematistiidæ.—Very close to the *Carangidæ*, and especially to the genus *Seriola*, is the small family of *Nematistiidæ*, containing the papagallo, *Nematistius pectoralis* of the west coast of Mexico. This large and beautiful fish has the general appearance of an amber-fish, but the dorsal spines are produced in long filaments. The chief character of the family is found in the excessive division of the rays of the pectoral fins.

The Bluefishes: Cheilodipteridæ.—Allied to the *Carangidæ* is the family of bluefishes (*Cheilodipteridæ*, or *Pomatomidæ*). The single species *Cheilodipterus saltatrix*, or *Pomatomus saltatrix*, known as the bluefish, is a large, swift, extremely voracious fish, common throughout most of the warmer parts of the Atlantic, but very irregularly distributed on the various coasts. Its distribution is doubtless related to its food. It is more abundant on our Eastern coast than anywhere else, and its chief food here is the menhaden. The bluefish differs from the *Carangidæ* mainly in its larger scales, and in a slight serration of the bones of the head. Its flesh is tender and easily torn. As a food-fish, rich, juicy, and delicate, it has few superiors.

Its maximum weight is from twelve to twenty pounds, but most of those taken are much smaller. It is one of the most voracious of all fish. Concerning this, Professor Baird observes:

"There is no parallel in point of destructiveness to the bluefish among the marine species on our coast, whatever may be the case among some of the carnivorous fish of the South American waters. The bluefish has been well likened to an animated chopping-machine the business of which is to cut to pieces and otherwise destroy as many fish as possible in a

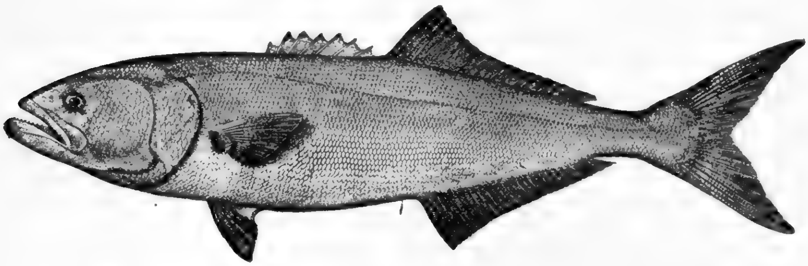


FIG. 218.—Bluefish, *Cheilodipterus saltatrix* (L.). New York.

given space of time. All writers are unanimous in regard to the destructiveness of the bluefish. Going in large schools in pursuit of fish not much inferior to themselves in size, they move along like a pack of hungry wolves, destroying everything before them. Their trail is marked by fragments of fish and by the stain of blood in the sea, as, where the fish is too large to be swallowed entire, the hinder portion will be bitten off and the anterior part allowed to float away or sink. It is even maintained with great earnestness that such is the gluttony of the fish, that when the stomach becomes full the contents are disgorged and then again filled. It is certain that it kills many more fish than it requires for its own support.

"The youngest fish, equally with the older, perform this function of destruction, and although they occasionally devour crabs, worms, etc., the bulk of their sustenance throughout the greater part of the year is derived from other fish. Nothing is more common than to find a small bluefish of six or eight inches in length under a school of minnows making continual dashes and captures among them. The stomachs of the blue-

fish of all sizes, with rare exceptions, are found loaded with the other fish, sometimes to the number of thirty or forty, either entire or in fragments.

"As already referred to, it must also be borne in mind that it is not merely the small fry that are thus devoured, and which it is expected will fall a prey to other animals, but that the food of the bluefish consists very largely of individuals which have already passed a large percentage of the chances against their reaching maturity, many of them, indeed, having arrived at the period of spawning. To make the case more clear, let us realize for a moment the number of bluefish that exist on our coast in the summer season. As far as I can ascertain by the statistics obtained at the fishing-stations on the New England coast, as also from the records of the New York markets, kindly furnished by Middleton & Carman, of the Fulton Market, the capture of bluefish from New Jersey to Monomoy during the season amounts to no less than one million individuals, averaging five or six pounds each. Those, however, who have seen the bluefish in his native waters and realized the immense numbers there existing will be quite willing to admit that probably not one fish in a thousand is ever taken by man. If, therefore, we have an actual capture of one million, we may allow one thousand millions as occurring in the extent of our coasts referred to, even neglecting the smaller ones, which, perhaps, should also be taken into account.

"An allowance of ten fish per day to each bluefish is not excessive, according to the testimony elicited from the fishermen and substantiated by the stomachs of those examined; this gives ten thousand millions of fish destroyed per day. And as the period of the stay of the bluefish on the New England coast is at least one hundred and twenty days, we have in round numbers twelve hundred million millions of fish devoured in the course of a season. Again, if each bluefish, averaging five pounds, devours or destroys even half its own weight of other fish per day (and I am not sure that the estimate of some witnesses of twice this weight is not more nearly correct), we will have, during the same period, a daily loss of twenty-five hundred million pounds, equal to three hundred thousand millions for the season.

"This estimate applies to three or four year old fish of at least three to five pounds in weight. We must, however, allow for those of smaller size, and a hundred-fold or more in number, all engaged simultaneously in the butchery referred to.

"We can scarcely conceive of a number so vast; and however much we may diminish, within reason, the estimate of the number of bluefish and the average of their capture, there still remains an appalling aggregate of destruction. While the smallest bluefish feed upon the diminutive fry, those of which we have taken account capture fish of large size, many of them, if not capable of reproduction, being within at least one or two years of that period.

"It is estimated by very good authority that of the spawn deposited by any fish at a given time not more than 30 per cent. are hatched, and that less than 10 per cent. attain an age when they are able to take care of themselves. As their age increases the chances of reaching maturity become greater and greater. It is among the small residuum of this class that the agency of the bluefish is exercised and whatever reasonable reduction may be made in our estimate, we cannot doubt that they exert a material influence.

"The rate of growth of the bluefish is also an evidence of the immense amount of food they must consume. The young fish which first appear along the shores of Vineyard Sound, about the middle of August, are about five inches in length. By the beginning of September, however, they have reached six or seven inches, and on their reappearance in the second year they measure about twelve or fifteen inches. After this they increase in a still more rapid ratio. A fish which passes eastward from Vineyard Sound in the spring weighing five pounds is represented, according to the general impression, by the ten- to fifteen-pound fish of the autumn. If this be the fact, the fish of three or four pounds which pass along the coast of North Carolina in March return to it in October weighing ten to fifteen pounds.

"As already explained, the relationship of these fish to the other inhabitants of the sea is that of an unmitigated butcher; and it is able to contend successfully with any other species not superior to itself in size. It is not known whether an

entire school ever unite in an attack upon a particular object of prey, as is said to be the case with the ferocious fishes of the South American rivers; should they do so, no animal, however large, could withstand their onslaught.

"They appear to eat anything that swims of suitable size—fish of all kinds, but perhaps more especially the menhaden, which they seem to follow along the coast, and which they atack with such ferocity as to drive them on the shore, where

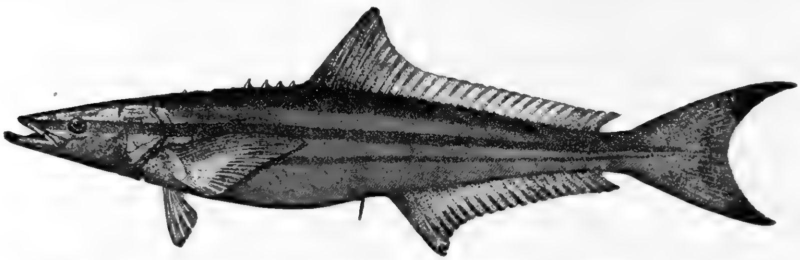


Fig. 219.—Sergeant-fish, *Rachycentron canadum* (Linnæus). Virginia.

they are sometimes piled up in windrows to the depth of a foot or more."

The Sergeant-fishes: Rachycentridæ.—The *Rachycentridæ*, or sergeant-fishes, are large, strong, swift, voracious shore fishes, with large mouths and small teeth, ranging northward from the warm seas. The dorsal spines are short and stout, separate from the fin, and the body is almost cylindrical, somewhat like that of the pike.

Rachycentron canadum, called cobia, crab-eater, snooks, or sergeant-fish, reaches a length of about five feet. The last name is supposed to allude to the black stripe along its side, like the stripe on a sergeant's trousers. It is rather common in summer along our Atlantic coast as far as Cape Cod, especially in Chesapeake Bay. *Rachycentron pondicerrianum*, equally voracious, extends its summer depredations as far as Japan. The more familiar name for these fishes, *Elacate*, is of later date than *Rachycentron*.

Mr. Prime thus speaks of the crab-eater as a game-fish:

"In shape he may be roughly likened to the great northern pike, with a similar head, flattened on the forehead. He is dark green on the back, growing lighter on the sides, but the

distinguishing characteristic is a broad, dark collar over the neck, from which two black stripes or straps, parting on the shoulders, extend, one on each side, to the tail. He looks as if harnessed with a pair of traces, and his behavior on a fly-rod is that of a wild horse. The first one that I struck, in the brackish water of Hillsborough River at Tampa, gave me a hitherto unknown sensation. The tremendous rush was not unfamiliar, but when the fierce fellow took the top of the water and went along lashing it with his tail, swift as a bullet, then descended, and with a short, sharp, electric shock left the line to come home free, I was for an instant confounded. It was all over in ten seconds. Nearly every fish that I struck after this behaved in the same way, and after I had got 'the hang of them' I took a great many."

The Butter-fishes: Stromateidæ.—The butter-fishes (*Stromateidæ*) form a large group of small fishes with short, compressed bodies, smooth scales, feeble spines, the vertebræ in increased number and especially characterized by the presence of a series of tooth-like processes in the œsophagus behind the pharyngeals. The ventral fins present in the young are often lost in the process of development.

According to Mr. Regan, the pelvic bones are very loosely attached to the shoulder-girdle as in the extinct genera *Platycormus* and *Homosoma*. This is perhaps a primitive feature, indicating the line of descent of these fishes from berycoid forms.

We unite with the *Stromateidæ* the groups or families of *Centrolophidæ* and *Nomeidæ*, knowing no characters by which to separate them.

Stromateus fiatola, the fiatola of the Italian fishermen, is an excellent food-fish of the Mediterranean. *Poronotus triacanthus*, the harvest-fish, or dollar-fish, of our Atlantic coast, is a common little silvery fish six to ten inches, as bright and almost as round as a dollar. Its tender oily flesh has an excellent flavor. Very similar to it is the poppy-fish (*Palometa simillima*) of the sandy shores of California, miscalled the "California pampano," valued by the San Francisco epicure, who pays large prices for it supposing it to be pampano, although admitting that the pampano in New Orleans has firmer flesh and

better flavor. The harvest-fish, *Peprilus paru*, frequently taken on our Atlantic coast, is known by its very high fins.

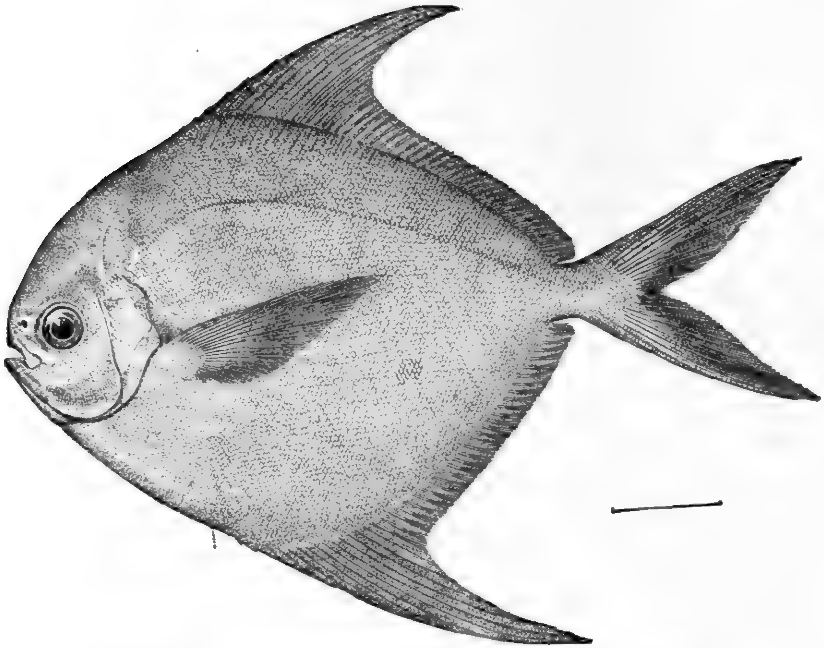


FIG. 220.—Harvest-fish, *Peprilus paru* (Linnæus). Virginia.

Stromateoides argenteus, a much larger fish than any of these, is a very important species on the coasts of China.

Psenopsis anomala takes the place of our butter-fishes in Japan, and much resembles them in appearance as in flavor.

To the *Stromateidæ* we also refer the black ruff of Europe, *Centrolophus niger*, an interesting deep-sea fish rarely straying to our coast. Allied to it is the black rudder-fish, *Palinurichthys perciformis*, common on the Massachusetts coast, where it is of some value as a food-fish. A specimen in a live-box once drifted to the coast of Cornwall, where it was taken uninjured, though doubtless hungry. Other species of ruff- and rudder-fish are recorded from various coasts.

Allied to the *Stromateidæ* are numerous fossil forms. *Omosoma sachelalmæ* and other species occur in the Cretaceous at Mount Lebanon. *Platycormus germanus*, with ctenoid scales

resembling a berycoid, but with the ventral rays I, 5, occurs in the Upper Cretaceous. Closely related to this is *Berycopsis elegans*, with smoother scales, from the English Chalk.

Gobiomorus gronovii (usually called *Nomeus gronovii*), the Portuguese man-of-war-fish, is a neat little fish about three inches long, common in the Gulf of Mexico and the Gulf Stream, where it hides from its enemies among the poisoned tentacles of the Portuguese man-of-war. Under the Portuguese man-of-war and also in or under large jelly-fishes several other species are found, notably *Carangus medusicola* and *Peprilus paru*. Many small species of *Psenes*, a related genus, also abound in the warm currents from tropical seas.

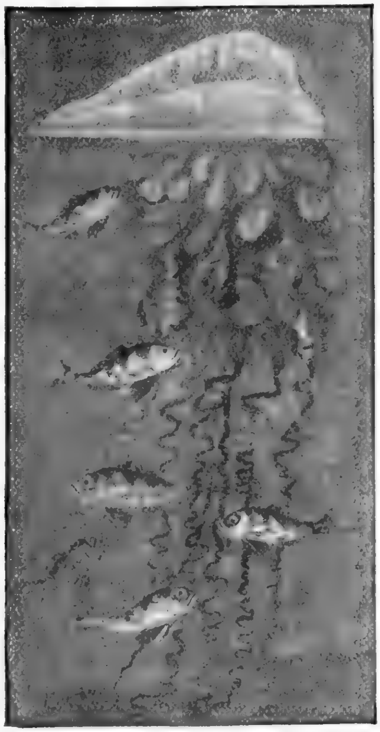


Fig. 221. — Portuguese Man-of-war Fish, *Gobiomorus gronovii*. Family *Stromateidæ*.

The Rag-fishes: Icosteidæ. — Allied to the butter-fishes are the deep-water *Icosteidæ*, fishes of soft, limp bodies as unresistent as a wet rag, *Icosteus ænigmaticus* of the California coast being known as ragfish. *Schedophilus medusophagus* feeds on medusæ and salpa, living on the surface in the deep seas. Mr. Ogilby thus speaks of a specimen taken in Ireland:

"It was the most delicate adult fish I ever handled; within twenty-four hours after its capture the skin of the belly and the intestines fell off when it was lifted, and it felt in the hand quite soft and boneless." A related species (*S. heathi*) has been lately taken by Dr. Charles H. Gilbert at Monterey in California.

The family of *Acrotidæ* contains a single species of large size. *Acrotus willoughbyi*, allied to *Icosteus*, but without ventral fins and with the vertebræ very numerous. The type, five and one-

quarter feet long, was thrown by a storm on the coast of Washington, near the Quinnault agency.

The family of *Zaproridæ* contains also a single large species, *Zaprora silenus*, without ventrals, but scaly and firm in substance. One specimen 2½ feet long was taken at Nanaimo on Vancouver Island and a smaller one at Victoria.

The Pomfrets: Bramidæ. — The *Bramidæ* are broad-bodied fishes of the open seas, covered with firm adherent scales. The flesh is firm and the skeleton heavy, the hypercoracoid especially much dilated. Of the various species the pomfret, or black bream (*Brama raii*), is the best known and most widely diffused. It reaches a length of two to four feet and is sooty black in color. It is not rare in Europe and has been occasionally taken at Grand Bank off Newfoundland, at the Bermudas, off the coast of Washington, on Santa Catalina Island, and in Japan. It is an excellent food-fish, but is seldom seen unless driven ashore by storms.

Steinegeria rubescens of the Gulf of Mexico is a little-known deep-sea fish allied to *Brama*, but placed by Jordan and Evermann in a distinct family, *Steinegeriidæ*.

Closely related to the *Bramidæ* is the small family of *Pteraclidæ*, silvery fishes with large firm scales, living near the surface in the ocean currents. In these fishes the ventral fins are placed well forward, fairly to be called jugular, and the rays of the dorsal and anal, all inarticulate or spine-like, are excessively prolonged. The species, none of them well known, are referred to four genera—*Pteraclis*, *Bentenia*, *Centropholis*, and *Velifer*. They are occasionally taken in ocean currents, chiefly about Japan and Madeira.

Fossil forms more or less remotely allied to the *Bramidæ* are recorded from the Eocene and Miocene. Among these are *Acanthonemus*, and perhaps *Pseudovomer*.

The Dolphins: Coryphænidæ. — The dolphins, or dorados (*Coryphænidæ*), are large, swift sea-fishes, with elongate, compressed bodies, elevated heads, sharp like the cut-water of a boat, and with the caudal fin very strong. The long dorsal fin, elevated like a crest on the head, is without spines. The high forehead characteristic of the dolphin is developed only in the adult male. The flesh of the dolphin is valued as food.

Its colors, golden-blue with deep-blue spots, fade rapidly at death, though the extent of this change has been much exaggerated. Similar changes of color occur at death in most bright-colored fishes, especially in those with thin scales. The common dolphin, or dorado (*Coryphæna hippurus*), is found in all warm

Fig. 222.—Dolphin or Dorado, *Coryphæna hippurus* Linnæus. New York.

seas swimming near the surface, as usual in predatory fishes, and reaches a length of about six feet. The small dolphin, *Coryphæna equisetis*, rarely exceeds 2½ feet, and is much more rare than the preceding, from which the smaller number of dorsal rays (53 instead of 60) best distinguishes it. Young dolphins of both species are elongate in form, the crest of the head not elevated, the physiognomy thus appearing very different from that of the adult. *Goniognathus coryphænoides* is an extinct dolphin of the Eocene.

The name dolphin, belonging properly to a group of small whales or porpoises, the genus *Delphinus*, has been unfortunately used in connection with this very different animal, which bears no resemblance to the mammal of the same name.

Other mackerel-like families not closely related to these occur in the warm seas. The *Leiognathidæ* are small, silvery fishes of the East Indies. *Leiognathus argentatus* (*Equula*) is very common in the bays of Japan, a small silvery fish of moderate value as food. *Gazza minuta*, similar, with strong teeth, abounds farther south. *Leiognathus fasciatum* is common in Polynesia. A fossil species called *Parequula albyi* occurs in the Miocene of Licata.

The *Kurtidæ* are small, short-bodied fishes of the Indian seas, with some of the ribs immovably fixed between rings

formed by the ossified cover of the air-bladder and with the hypocoracoid obsolete. *Kurtus indicus* is the principal species.

The Menidæ.—Near the *Kurtidæ* we may perhaps place the family of *Menidæ*, of one species, *Mene maculata*, the moon-fish of the open seas of the East Indies and Japan. This is a small fish, about a foot long, with the body very closely compressed, the fins low and the belly, through the extension of the pelvic bone, a good deal more prominent than the back. The ventral

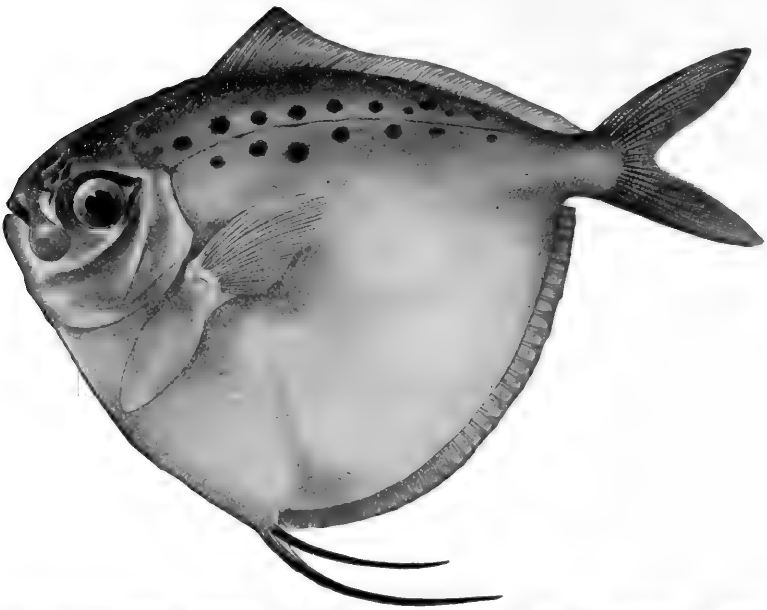


FIG. 223.—*Mene maculata* (Bloch & Schneider). Family Menidæ. Japan.

fins have the usual number of one spine and five soft rays, a character which separates *Mene* widely from *Lampris*, which in some ways seems allied to it.

Another species of *Menidæ* is the extinct *Gasteronemus rhombeus* of the Eocene of Monte Bolca. It has much the same form, with long pubic bones. The very long ventral fins are, however, made of one spine and one or two rays. A second species, *Gasteronemus oblongus*, is recorded from the same rocks.

The Pempheridæ.—The *Pempheridæ*, "deep-water catalufas," or "magifi," are rather small deep-bodied fishes, reddish in color, with very short dorsal, containing a few graduated spines.

and with a very long anal fin. These inhabit tropical seas at moderate depths. *Pempheris* bears a superficial resemblance to

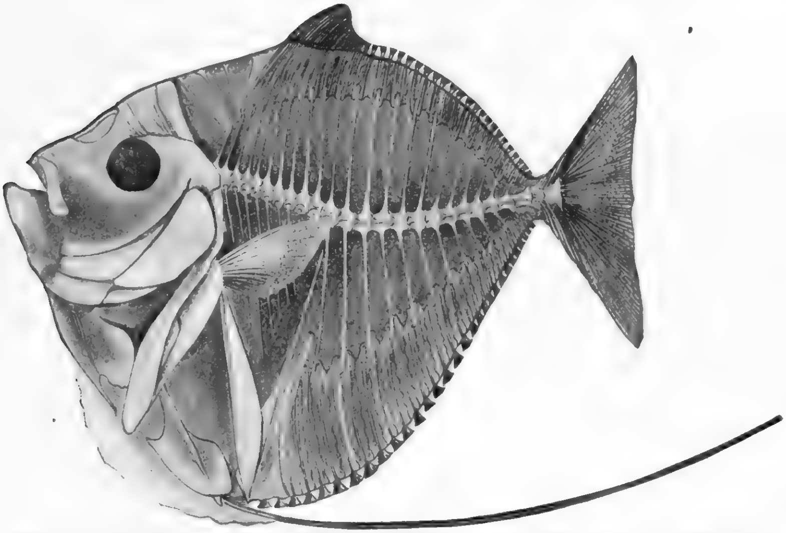


FIG. 224.—*Gasteronemus rhombeus* Agassiz. (After Woodward.) Menidæ.

Beryx, but, according to Starks, this resemblance is not borne out by the anatomy. *Pempheris mulleri* and *P. poeyi* are found

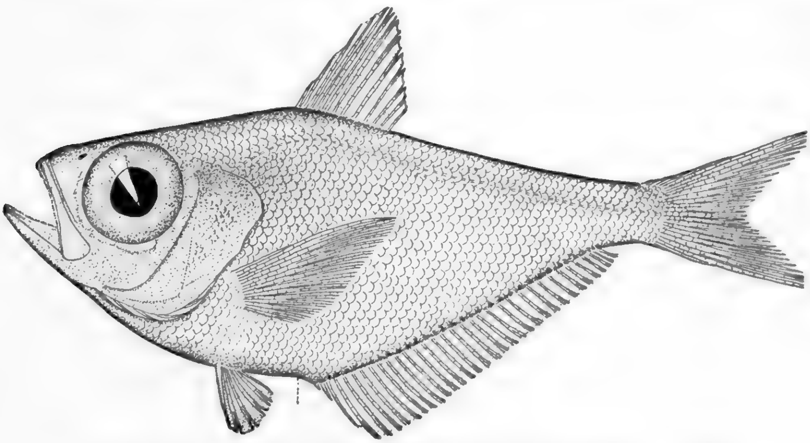


FIG. 225.—Catalufa de lo Alto, *Pempheris mulleri* Poey. Havana.

in the West Indies. *Pempheris otaitensis* and *P. mangula* range through Polynesia.

Very close to the *Pempheridæ* is the small family of *Bathyclupeidæ*. These are herring-like fishes, much compressed and

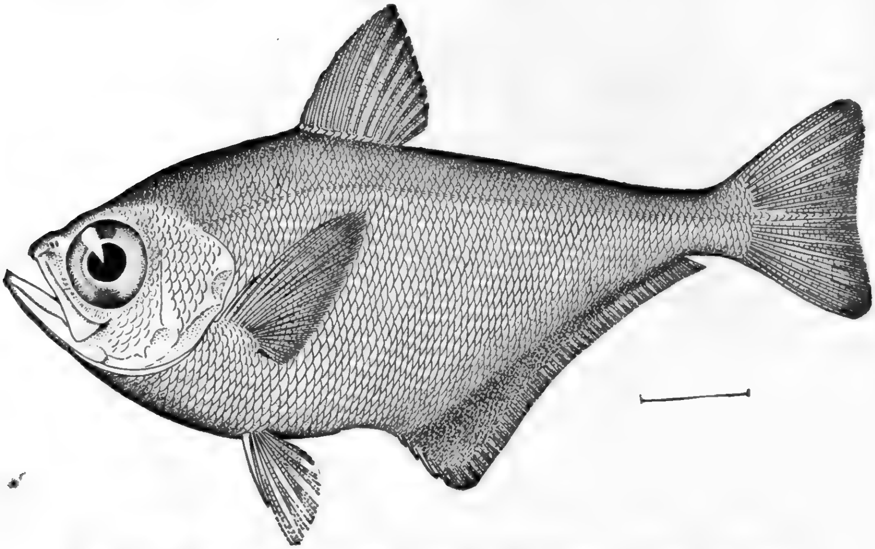


Fig. 226.—*Pempheris nyctereutes* Jordan & Evermann. Giran, Formosa.

with a duct to the air-bladder. There are but one or two dorsal spines. The ventrals are of one spine and five rays as in perch, like fishes, but placed behind the pectoral fins. This feature-due to the shortening of the belly, is regarded by Alcock, the discoverer, as a result of degeneration, and the family was

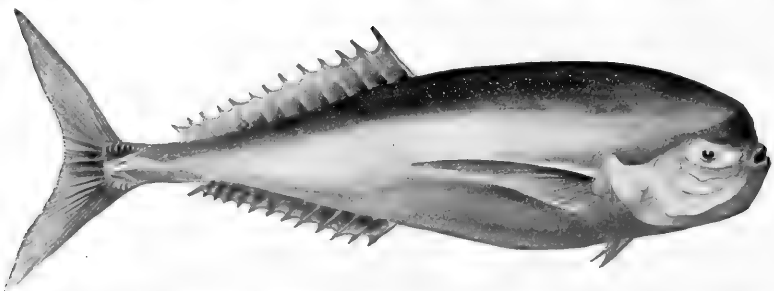


Fig. 227.—The Louvar, *Luvarus imperialis* Rafinesque. Family Luvaridæ. (After Day.)

placed by him among the herrings. The persistent air-duct excludes it from the *Percesoces*, the normally formed ventrals from the *Berycoidei*. If we trust the indications of the skeleton,

we must place the family with *Pempheris*, near the scombroid fishes.

Luvaridæ.—Another singular family is the group of *Louvars, Luvaridæ. Luvaris imperialis.* The single known species is a large, plump, voracious fish, with the dorsal and anal rays all unbranched, and the scales scurf-life over the smooth skin. It is frequently taken in the Mediterranean, and was found on the island of Santa Catalina, California, by Mr. C. F. Holden.

The Square-tails: Tetragonuridæ.—The *Tetragonuridæ* are long-bodied fishes of a plump or almost squarish form, covered with hard, firm, very adherent scales. *Tetragonurus cuvieri*, the single species, called square-tail, or escolar de natura, is a curious fish, looking as if whittled out of wood, covered with a compact armor of bony scales, and swimming very slowly in deep water. It is known from the open Atlantic and Mediterranean and has been once taken at Wood's Hole in Massachusetts. According to Mr. C. T. Regan the relations of this eccentric fish are with the *Stromateidæ* and *Bramidæ*, the skeleton being essentially that of *Stromateus*, and Boulenger places both *Tetragonurus* and *Stromateus* among the *Percesoces*.

The Crested Band-fishes: Lophotidæ.—The family of *Lophotidæ* consists of a few species of deep-sea fishes, band-shaped, naked, with the dorsal of flexible spines beginning as a high crest on the elevated occiput. The first spine is very strong. The ventrals are thoracic with the normal number, I, 5, of fin-rays. *Lophotes cepedianus*, the crested bandfish, is occasionally taken in the Mediterranean in rather deep water. *Lophotes capellei* is rarely taken in the deep waters of Japan.

It is thought that the *Lophotidæ* may be related to the ribbon-fishes, *Tæniosomi*, but on the whole they seem nearer to the highly modified *Scombroidei*, the *Pteraclidæ* for example.

In a natural arrangement, we should turn from the *Bramidæ* to the *Antigoniidæ* and the *Ilarchidæ*, then passing over the series which leads through *Chætodontidæ* and *Teuthidæ* to the *Plectognaths*. It is, however, necessary to include here, alongside the mackerels, though not closely related to them, the parallel series of perch-like fishes, which at the end become also hopelessly entangled, through aberrant forms, with other

series of which the origin and relations are imperfectly understood. As the relations of forms cannot be expressed in a linear series, many pages must intervene before we can take up the supposed line of development from the Scombroid fishes to those called *Squamipinnes.*

CHAPTER XVIII

PERCOIDEA, OR PERCH-LIKE FISHES

PERCOID Fishes.—We may now take up the long series of the *Percoidea*, the fishes built on the type of the perch or bass. This is a group of fishes of diverse habits and forms, but on the whole representing better than any other the typical *Acanthopterygian* fish. The group is incapable of concise definition, or, in general, of any definition at all; still, most of its members are definitely related to each other and bear in one way or another a resemblance to the typical form, the perch, or more strictly to its marine relatives, the sea-bass, or *Serranidæ*. The following analysis gives most of the common characters of the group:

Body usually oblong, covered with scales, which are typically ctenoid, not smooth nor spinous, and of moderate size. Lateral line typically present and concurrent with the back. Head usually compressed laterally and with the cheeks and opercles scaly. Mouth various, usually terminal and with lateral cleft; the teeth various, but typically pointed, arranged in bands on the jaws, and in several families on the vomer and palatine bones also, as well as on the pharyngeals; gill-rakers usually sharp, stoutish, armed with teeth, but sometimes short or feeble; lower pharyngeals almost always separate, usually armed with cardiform teeth; third upper pharyngeal moderately enlarged, elongate, not articulated to the cranium, the fourth typically present; gills four, a slit behind the fourth; gill membranes free from the isthmus, and usually not connected with each other; pseudobranchiæ typically well developed. Branchiostegals few, usually six or seven. No bony stay connecting the suborbital chain to the preopercle. Opercular bones all well developed, normal in position; the preopercle typically serrate. No cranial spines. Dorsal fin

variously developed, but always with some spines in front, these typically stiff and pungent; anal fin typically short, usually with three spines, sometimes with a larger number, rarely with none; caudal fin various, usually lunate; pectoral fins well developed, inserted high; ventral fins always present, thoracic, separate, almost always with one spine and five rays, the *Aphredoderidæ* having more, a few *Serranidæ* having fewer. Air-bladder usually present, without air-duct in adult; simple and generally adherent to the walls of the abdomen. Stomach cæcal, with pyloric appendages, the intestines short in most species, long in the herbivorous forms. Vertebral column well developed, none of the vertebræ especially modified, the number $10+14=24$, except in certain extratropical and fresh-water forms, which retain primitive higher numbers. Shoulder-girdle normally developed, the post-temporal bifurcate attached to the skull, but not coossified with it; none of the epipleural bones attached to the center of the vertebræ; coracoids normal, the hypercoracoid always with a median foramen, the basal bones of the pectoral (actinosts or pterygials) normally developed, three or four in number, hour-glass-shaped, longer than broad; premaxillary forming the border of the mouth usually protractile; bones of the mandible distinct. Orbitosphenoid wanting.

The most archaic of the perch-like types are apparently some of those of the fresh waters. Among these the process of evolution has been less rapid. In some groups, as the *Percidæ*, the great variability of species is doubtless due to the recent origin, the characters not being well fixed.

The Pirate-perches: Aphredoderidæ.—Among the most remarkable of the living percoid fishes and probably the most primitive of all, showing affinities with the *Salmopercæ*, is the pirate-perch, *Aphredoderus sayanus*, a little fish of the lowland streams of the Mississippi Valley. The family of *Aphredoderidæ* agrees with the berycoid fishes in scales and structure of the fins, and Boulenger places it with the Berycidæ. Starks has shown, however, that it lacks the orbitosphenoid, and the general osteology is that of the perch-like fishes. The dorsal and anal have a few spines. The thoracic ventrals have one spine and eight rays. There is no adipose fin and probably no duct to the air-bladder. A singular trait is found in the posi-

tion of the vent. In the adult this is in front of the ventral fins, at the throat. In the young it is behind the ventral fins

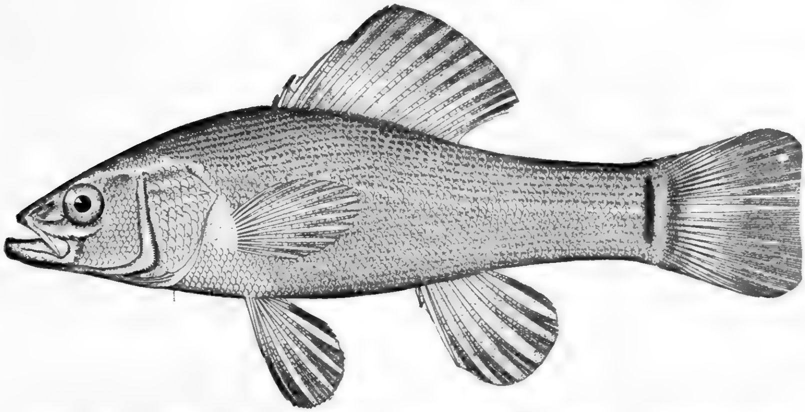


FIG. 228.—Pirate Perch, *Aphredoderus sayanus* (Gilliams). Illinois River.

as in ordinary fishes. With age it moves forward by the prolongation of the horizontal part of the intestine or rectum. The same peculiar position of the vent is found in the berycoid genus *Paratrachichthys*.

In the family *Aphredoderidæ* but one species is known, *Aphredoderus sayanus*, the pirate-perch. It reaches a length

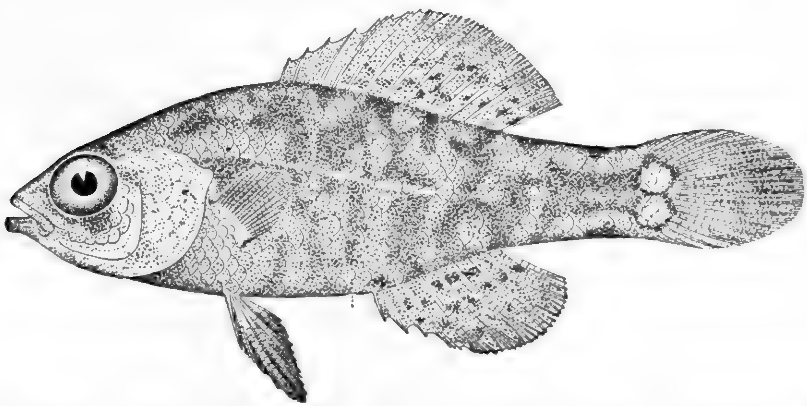


FIG 229.—Everglade Pigmy Perch, *Elassoma evergladei* Jordan. Everglades of Florida.

of five inches and lives in sluggish lowland streams with muddy bottom from New Jersey and Minnesota to Louisiana. It is

dull green in color and feeds on insects and worms. It has no economic value, although extremely interesting in its anatomy and relationship.

Whether the *Asineopidæ*, fresh-water fishes of the American Eocene, and the *Erismatopteridæ*, of the same deposits (see page 235) are related to *Aphredoderus* or to *Percopsis* is still uncertain.

The Pigmy Sunfishes: Elassomidæ.—One of the most primitive groups is that of *Elassomidæ*, or pigmy sunfishes. These are

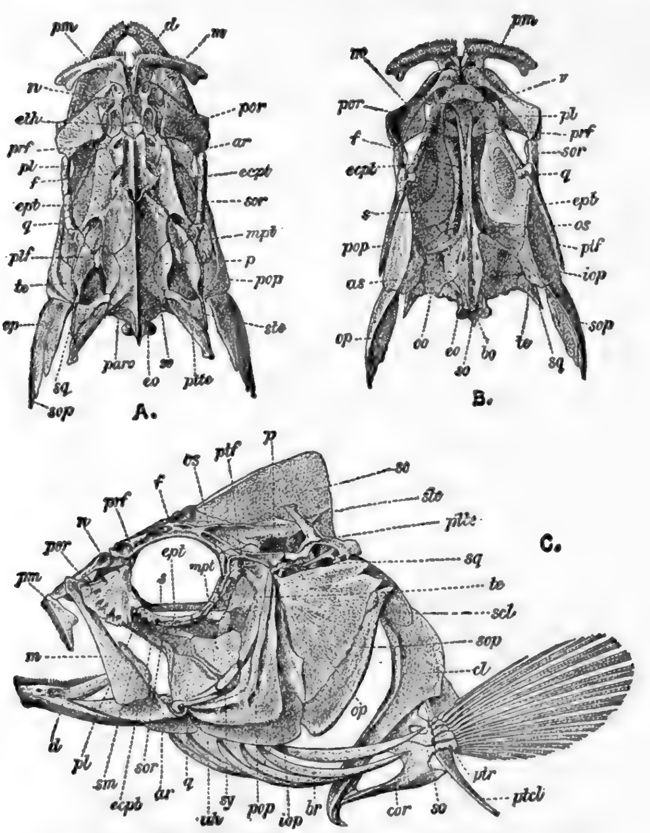


FIG. 230.—Skull of the Rock Bass, *Ambloplites rupestris.*

very small fishes, less than two inches long, living in the swamps of the South, resembling the sunfishes, but with the number of dorsal spines reduced to from three to five. *Elassoma zonatum* occurs from southern Illinois to Louisiana. *Elassoma evergladei* abounds in the Everglades of Florida. In both the body

is oblong and compressed, the color is dull green crossed by black bars or blotches.

The Sunfishes: Centrarchidæ.—The large family of *Centrarchidæ*, or sunfishes, is especially characteristic of the rivers of the eastern United States, where the various species are inordinately abundant. The body is relatively short and deep, and the axis passes through the middle so that the back has much the same outline as the belly. The pseudobranchiæ are imperfect, as in many fresh-water fishes, and the head is feebly armed, the bones being usually without spines or serratures. The colors are often brilliant, the sexes alike, and all are carnivorous, voracious, and gamy, being excellent as food. The origin of the group is probably Asiatic, the fresh-water serranoid of Japan, *Bryttosus*, resembling in many ways an American sunfish, and the genus *Kuhlia* of the Pacific showing many homologies with the black bass, *Micropterus*.

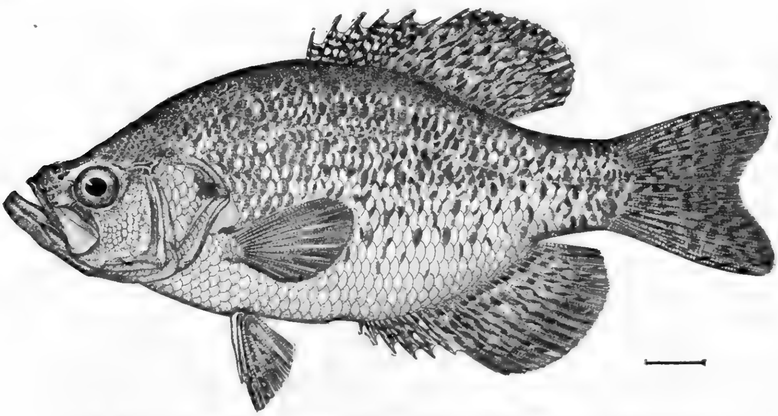


FIG. 231.—Crappie, *Pomoxis annularis* Rafinesque. Ohio River.

Crappies and Rock Bass. — *Pomoxis annularis*, the crappie, and *Pomoxis sparoides*, the calico-bass, are handsome fishes, valued by the angler. These are perhaps the most primitive of the family, and in these species the anal fin is larger than the dorsal. The flier, or round bass, *Centrarchus macropterus*, with eight anal spines, is abundant in swamps and lowland ponds of the Southern States. It is a pretty fish, attractive in the aquarium. *Acantharchus pomotis* is the mud-bass of the Delaware, and *Archoplites interruptus*, the

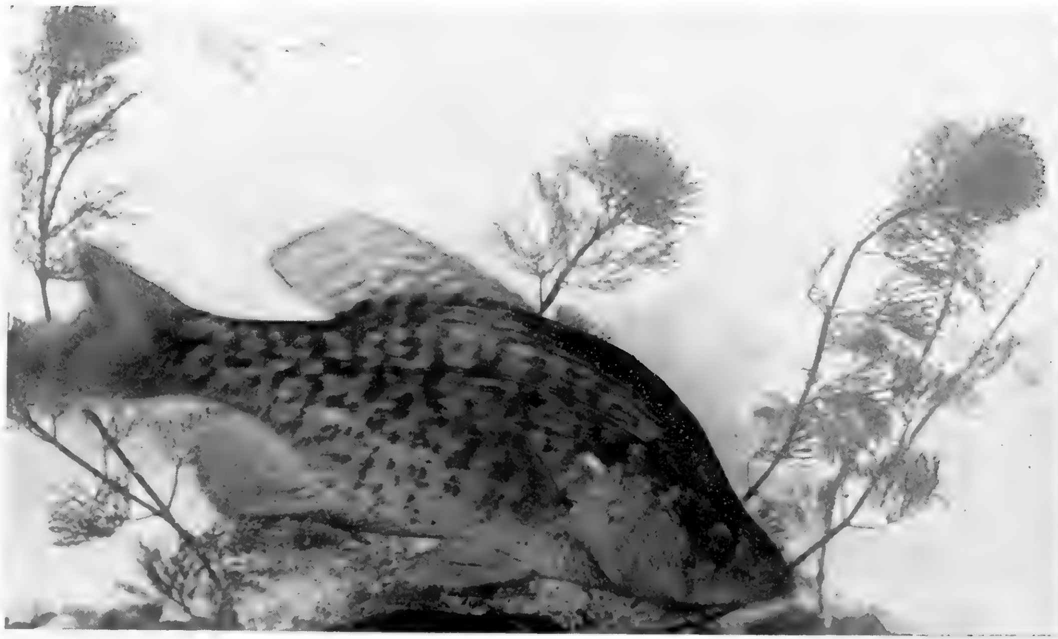


FIG. 232.—Crappie, *Pomoxis annularis* (Raf.). (From life by Dr. R. W. Shufeldt.)

"perch" of the Sacramento. The latter is a large and gamy fish, valued as food and interesting as being the only fresh-

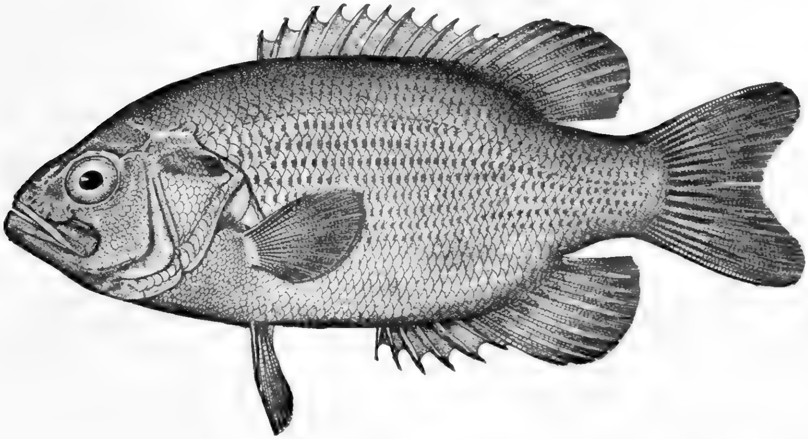


Fig. 233.—Rock Bass, *Ambloplites rupestris* (Rafinesque.) Ecorse, Mich.

water fish of the nature of perch or bass native to the west of the Rocky Mountains. The numbers of this species, according

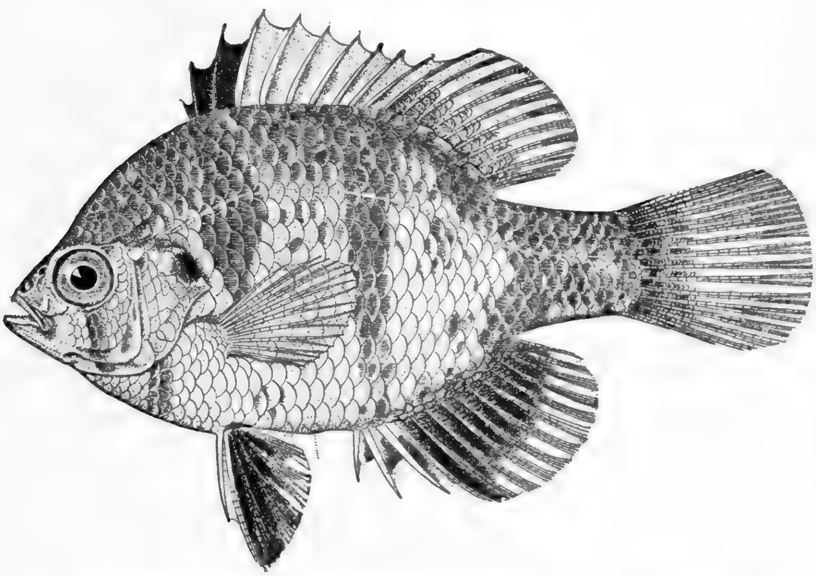


Fig. 234.—Banded Sunfish, *Mesogonistius chætodon* (Baird). Delaware River.

to Mr. Will S. Green of Colusa, California, have been greatly reduced by the introduction of the catfish (*Ameiurus nebulosus*)

into the Sacramento. The perch eats the young catfish, and its stomach is torn by their sharp pectoral spines. Another

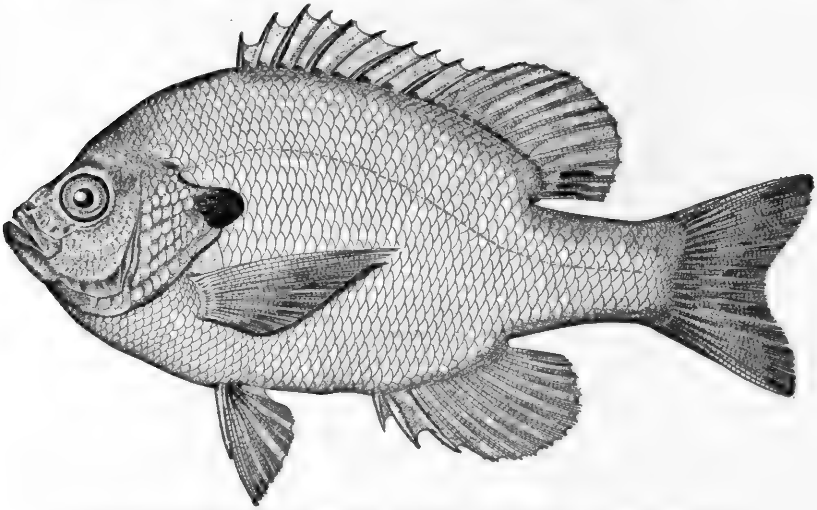


FIG. 235.—Blue-Gill, *Lepomis pallidus* (Mitchill). Potomac River.

species of this type is the warmouth (*Chænobryttus gulosus*) of the ponds of the South, and still more familiar rock-bass

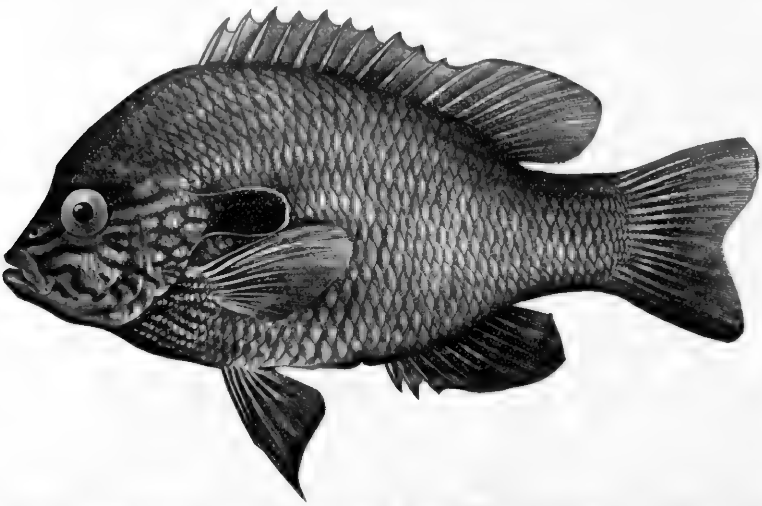


FIG. 236.—Long-eared Sunfish, *Lepomis megalotis* (Rafinesque). From Clear Creek, Bloomington, Indiana. Family *Centrarchidæ*.

or redeye (*Ambloplites rupestris*) of the more northern lakes and rivers valued as a game- and food-fish. A very pretty

aquarium fish is the black-banded sunfish, *Mesogonistius chætodon*, of the Delaware, as also the nine-spined sunfish, *Enneacanthus gloriosus*, of the coast streams southward. *Apomotis cyanellus*, the blue-green sunfish or little redeye, is very widely distributed from Ohio westward, living in every brook. The dissection of this species is given on page 26, Vol. I. To *Lepomis* belong numerous species having the opercle prolonged in a long flap which is always black in color, often with a border of scarlet or blue. The yellowbelly of the South (*Lepomis auritus*), ear-like the showily colored long-eared sunfish (*Lepomis megalotis*) of the

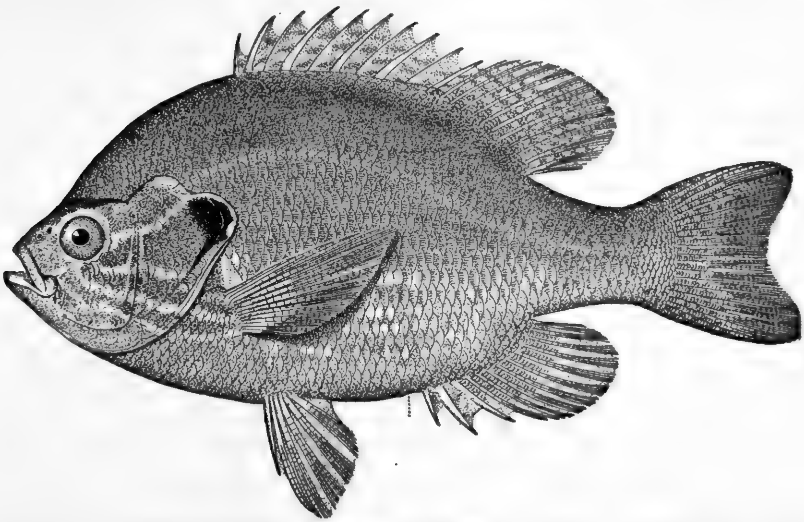


FIG. 237.—Common Sunfish, *Eupomotis gibbosus* (Linnæus). Root River, Wis.

southwest, figured on page 2, Vol. I, the bluegill (*Lepomis pallidus*), abundant everywhere south and west of New York, are members of this genus. The genus *Eupomotis* differs in its larger pharyngeals, which are armed with blunt teeth. The common sunfish, or pumpkinseed, *Eupomotis gibbosus*, is the most familiar representative of the family, abounding everywhere from Minnesota to New England, then south to Carolina on the east slope of the Alleghanies, breeding everywhere in ponds and in the eddies of the clear brooks.

The Black Bass.—The black bass (*Micropterus*) belong to the same family as the sunfish, differing in the larger size, more elongate form, and more voracious habit. The two species are

among the most important of American game-fishes, abounding in all clear waters east of the Alleghanies and resisting the evils of civilization far better than the trout.

The small-mouthed black bass, *Micropterus dolomieu*, is the most valuable of the species. Its mouth, although large, is relatively small, the cleft not extending beyond the eye. The green coloration is broken in the young by bronze cross-bands. The species frequents only running streams, preferring clear and cold waters, and it extends its range from Canada as far to the southward as such streams can be found. Dr. James A. Henshall, an accomplished angler, author of the "Book of the Black Bass," says: "The black bass is eminently an American fish; he has the faculty of asserting himself and of making himself completely at home wherever placed. He is plucky, game, brave, unyielding to the last when hooked. He has the arrowy rush and vigor of a trout, the untiring strength and bold leap of a salmon, while he has a system of fighting tactics peculiarly his own. I consider him inch for inch and pound for pound the gamest fish that swims."

In the same vein Charles Hallock writes: "No doubt the bass is the appointed successor of the trout; not through heritage, nor selection, nor by interloping, but by foreordination. Truly, it is sad to contemplate, in the not distant future, the extinction of a beautiful race of creatures, whose attributes have been sung by all the poets; but we regard the inevitable with the same calm philosophy with which the astronomer watches the burning out of a world, knowing that it will be succeeded by a new creation. As we mark the soft varitinted flush of the trout disappear in the eventide, behold the sparkle of the coming bass, as he leaps in the morning of his glory! We hardly know which to admire the most—the velvet livery and the charming graces of the departing courtier, or the flash of the armor-plates of the advancing warrior. The bass will unquestionably prove himself a worthy substitute for his predecessor and a candidate for a full legacy of honors.

"No doubt, when every one of the older states shall become as densely settled as Great Britain itself, and all the rural aspects of the crowded domain resemble the suburban surroundings of our Boston; when every feature of the pastoral landscape

shall wear the finished appearance of European lands, and every verdant field be closely cropped by lawn-mowers and guarded by hedges, and every purling stream which meanders through it has its water-bailiff, we shall still have speckled trout from which the radiant spots have faded, and tasteless fish, to catch at a dollar a pound (as we already have on Long Island), and all the appurtenances and appointments of a genuine English trouting privilege and a genuine English 'outing.'

"In those future days, not long hence to come, some venerable piscator, in whose memory still lingers the joy of fishing, the brawling stream which tumbled over the rocks in the tangled wildwood, and moistened the arbutus and the bunchberries

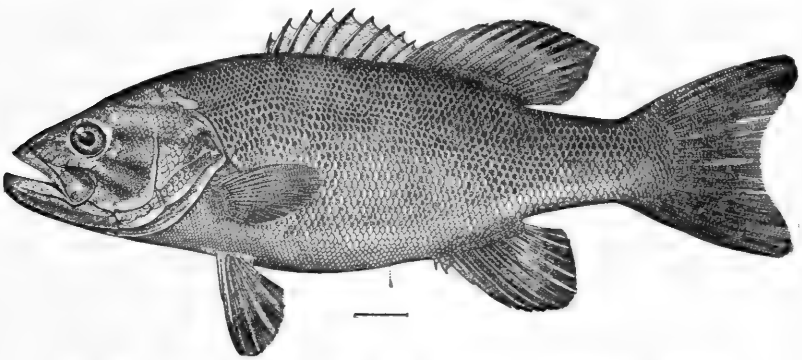


FIG. 238.—Small Mouth Black Bass *Micropterus dolomieu* Lacèpede.

which garnished its banks, will totter forth to the velvet edge of some peacefully flowing stream, and having seated himself on a convenient point in a revolving easy-chair, placed there by his careful attendant, cast right and left for the semblance of sport long dead.

"Hosts of liver-fed fish rush to the signal for their early morning meal, and from the center of the boil which follows the fall of the handfuls thrown in my piscator of the ancient days will hook a two-pound trout, and play him hither and yon, from surface to bottom, without disturbing the pampered gourmands which are gorging themselves upon the disgusting viands; and when he has leisurely brought him to land at last, and the gillie has scooped him with his landing-net, he will feel in his capacious pocket for his last trade dollar, and giving his friend the tip, shuffle back to his house, and lay aside his rod forever."

The black bass is now introduced into the streams of Europe and California. There is little danger that it will work injury to the trout, for the black bass prefers limestone streams, and the trout rarely does well in waters which do not flow over granite rock or else glacial gravel.

The large-mouth black bass (*Micropterus salmoides*) is very much like the other in appearance. The mouth is larger, in the adult cleft beyond the eye; the scales are larger, and in the young there is always a broad black stripe along the sides and no cross-bands. The two are found in the same region, but almost never in the same waters, for the large-mouth bass is a fish of the lakes, ponds, and bayous, always avoiding the swift currents. The young like to hide among weeds or beneath lily-pads. From its preference for sluggish waters, its range extends farther to the southward, as far as the Mexican State of Tamaulipas.

Plioplarchus is a genus of fossil sunfishes from the Eocene of South Dakota and Oregon. *Plioplarchus sexspinosus, septemspinosus*, and *whitei* are imperfectly known species.

The Saleles: Kuhliidæ.—Much like the sunfishes in anatomy, though more like the white perch in appearance and habit, are the members of the little family of *Kuhliidæ*. These are active silvery perches of the tropical seas, ponds, and river-mouths, especially abundant in Polynesia. *Kuhlia malo* is the aholehole of the Hawaiians, a silvery fish living in great numbers in brackish waters. *Kuhlia rupestris*, the salele of the Samoan rivers, is a large swift fish of the rock pools, in form, color, and habits remarkably like the black bass. It is silvery bronze in hue, everywhere mottled with olive-green. The sesele, *Kuhlia marginata*, lives with it in the rivers, but is less abundant. The saboti, *Kuhlia tæniura*, a large silvery fish with cross-bands on the caudal fin, lives about lava-rocks in Polynesia from the Galapagos to Samoa and the East Indies, never entering rivers. Still other species are found in the rock pools and streams of Japan and southward.

The skeleton in *Kuhlia* is essentially like that of the black bass, and Dr. Boulenger places the genus with the *Centrarchidæ*.

The True Perches: Percidæ.—The great family of *Percidæ* includes fresh-water fishes of the northern hemisphere, elon-

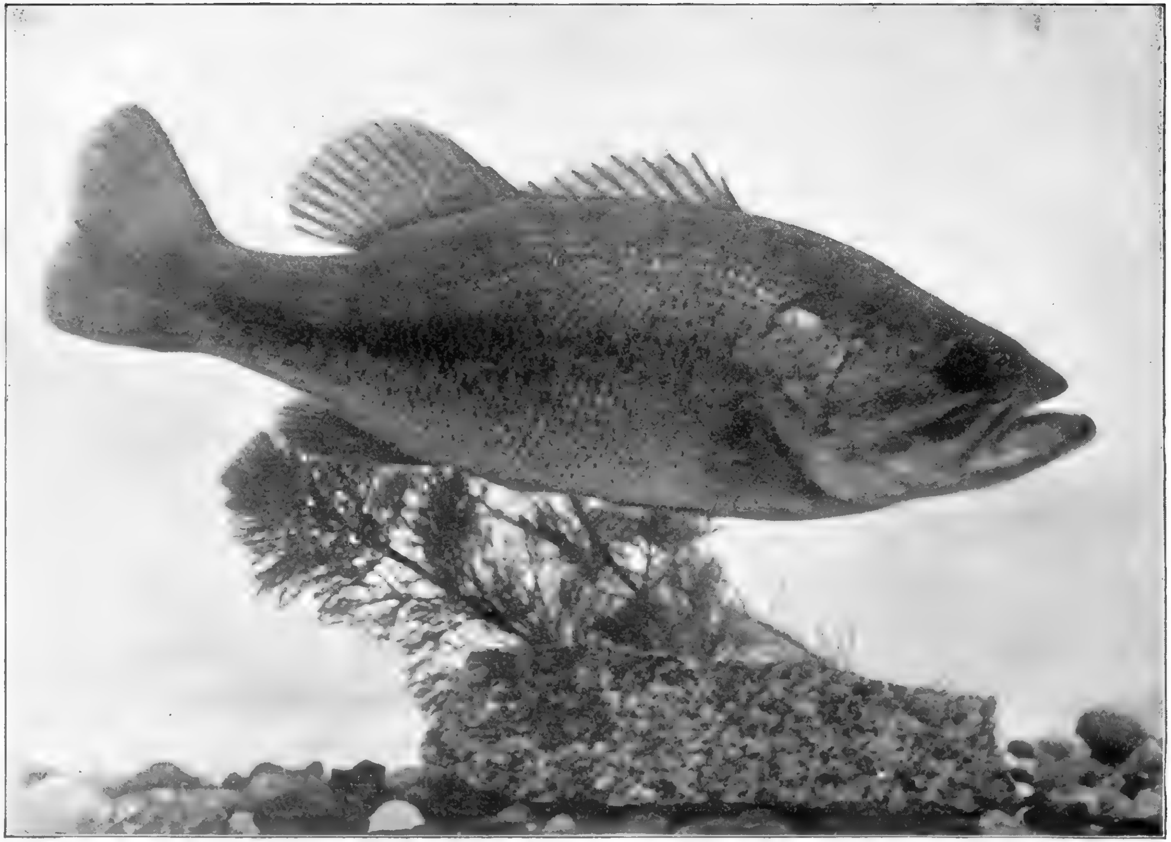


FIG. 239.—Large-mouthed Black Bass, *Micropterus salmoides* (Lac.). (From life by Dr. R. W. Shufeldt.)

gate in body, with the vertebræ in increased number and with only two spines in the anal fin. About ninety species are recorded, the vast majority being American. The dwarf perches, called darters (*Etheostominæ*), are especially characteristic of the clear streams to the eastward of the plains of the Missouri. These constitute one of the greatest attractions of our American river fauna. They differ from the perch and its European allies in their small size, bright colors, and large fins, and more technically in the rudimentary condition of the pseudobranchiæ and the air-bladder, both of which organs are almost inappreciable. The preopercle is unarmed, and the number of the branchiostegals is six. The anal papilla is likewise developed, as in the *Gobiidæ*, to which group the darters bear a considerable superficial resemblance, which, however, indicates no real affinity.

Relations of Darters to Perches.—The colors of the *Etheostominæ*, or darters, are usually very brilliant, species of *Etheostoma* especially being among the most brilliantly colored fishes known; the sexual differences are often great, the females being, as a rule, dull in color and more speckled or barred than the males. Most of them prefer clear running water, where they lie on the bottom concealed under stones, darting, when frightened or hungry, with great velocity for a short distance, by a powerful movement of the fan-shaped pectorals, then stopping as suddenly. They rarely use the caudal fin in swimming, and they are seldom seen floating or moving freely in the water like most fishes. When at rest they support themselves on their expanded ventrals and anal fin. All of them can turn the head from side to side, and they frequently lie with the head in a curved position or partly on one side of the body. The species of *Ammocrypta*, and perhaps some of the others, prefer a sandy bottom, where, by a sudden plunge, the fish buries itself in the sand, and remains quiescent for hours at a time with only its eyes and snout visible. The others lurk in stony places, under rocks and weeds. Although more than usually tenacious of vitality, the darters, from their bottom life, are the first to be disturbed by impurities in the water. All the darters are carnivorous, feeding chiefly on the larvæ of *Diptera*, and in their way voracious. All are of small size; the largest (*Percina rex*) reaches a length of ten inches,

while the smallest (*Microperca punctulata*) is, one of the smallest spiny-rayed fishes known, barely attaining the length of an inch and a half. In Europe no *Etheostominæ* are found, their place being filled by the genera *Zingel* and *Aspro*, which bear a strong resemblance to the American forms, a resemblance which may be a clew to the origin of the latter.

The Perches. — The European perch, *Perca fluviatilis*, is placed by Cuvier at the head of the fish series, as representing in a high degree the traits of a fish without sign of incomplete development on the one hand or of degradation on the other. Doubtless the increased number of the vertebræ is the chief character which would lead us to call in question this time-honored arrangement. Because, however, the perch has a relatively degenerate vertebrate column, we have used an allied form, the striped bass, as a fairer type of the perfected spiny-rayed fish. Certainly the bass represents this type better than the perch.

But though we may regard the perch as nearest the typically perfect fish, it is far from being one of the most highly specialized, for, as we have seen in several cases, a high degree of specialization of a particular structure is a first step toward its degradation.

The perch of Europe is a common game-fish of the rivers. The yellow perch of America (*Perca flavescens*) is very much like it, a little brighter in color, olive and golden with dusky cross-bands. It frequents quiet streams and ponds from Minnesota eastward, then southward east of the Alleghanies. "As a still-pond fish," says Dr. Charles Conrad Abbott, "if there is a fair supply of spring-water, they thrive excellently; but the largest specimens come either from the river or from the inflowing creeks. Deep water of the temperature of ordinary spring-water, with some current and the bed of the stream at least partly covered with vegetation, best suits this fish." The perch is a food-fish of moderate quality. In spite of its beauty and gaminess, it is little sought for by our anglers, and is much less valued with us than is the European perch in England. But Dr. Goode ventures to prophesy that "before many years the perch will have as many followers as the black bass among those who fish for pleasure" in the region it inhabits. "A

fish for the people it is, we will grant, and it is the anglers from among the people who have neither time nor patience for long trips nor complicated tackle who will prove its steadfast friends." The boy values it, according to Thoreau. When he returns from the mill-pond, he numbers his perch as "real fishes." "So many unquestionable fish he counts, and so many chubs, which he counts, then throws away."

In the perch, the oral valves, characteristic of all bony fishes, are well developed. These structures recently investigated by

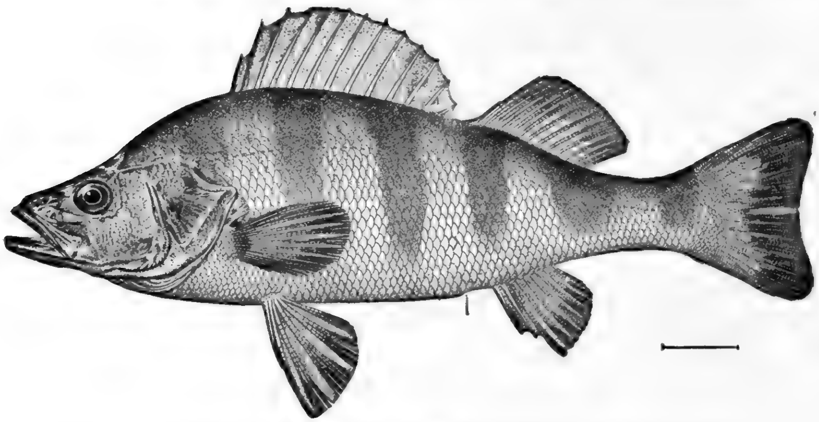


Fig. 240.—Yellow Perch, *Perca flavescens* Mitchill. Potomac River.

Evelyn G. Mitchill, form a fold of connective tissue just behind the premaxillary and before the vomer. They are used in respiration, preventing the forward flow of water as the mouth closes.

Several perch-like fishes are recorded as fossils from the Miocene.

Allied to the perch, but long, slender, big-mouthed, and voracious, is the group of pike perches, found in eastern America and Europe. The wall-eye, or glass-eye (*Stizostedion vitreum*), is the largest of this tribe, reaching a weight of ten to twenty pounds. It is found throughout the region east of the Missouri in the large streams and ponds, an excellent food-fish, with white, flaky flesh and in the north a game fish of high rank. The common names refer to the large glassy eye, concerning which Dr. Goode quotes from some "ardent admirer" these words: "Look at this beautiful fish, as symmetrical in form as the salmon. Not a fault in his make-up, not a scale

disturbed, every fin perfect, tail clean-cut, and his great, big wall-eyes stand out with that life-like glare so characteristic of the fish."

Similar to the wall-eye, but much smaller and more translucent in color, is the sauger, or sand-pike, of the Great Lakes and

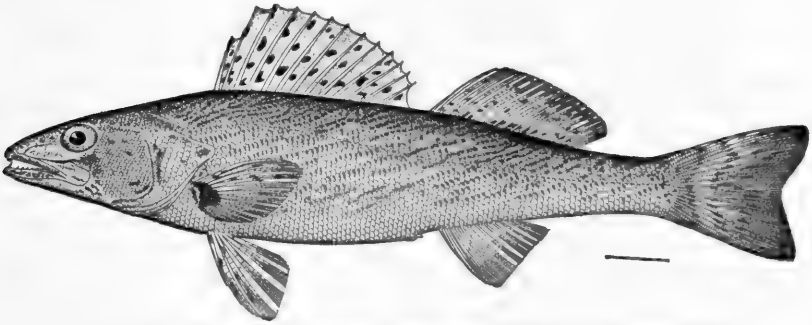


FIG. 241.—Sauger, *Stizostedion canadense* (Smith). Ecorse, Mich

Northern rivers, *Stizostedion canadense*. This fish rarely exceeds fifteen inches in length, and as a food-fish it is of correspondingly less importance.

The pike-perch, or zander, of central Europe, *Centropomus* (or *Sandrus*) *lucioperca*, is an excellent game-fish, similar to

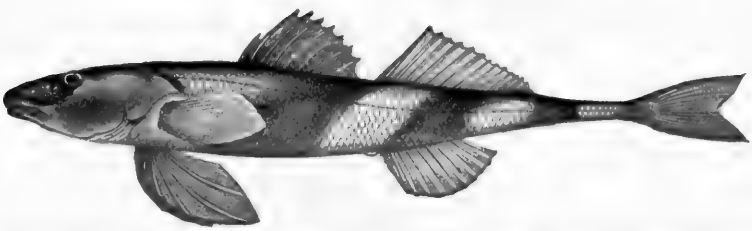


FIG. 242.—The Aspron, *Aspro asper* (Linnæus). Rhone River. Family *Percidæ*. (After Seelye.)

the sauger, but larger, characterized technically by having the ventral fins closer together. Another species, *Centropomus volgensis*, in Russia, looks more like a perch than the other species do. *Sandroserrus*, a fossil pike-perch, occurs in the Pliocene. Another European fish related to the perch is the river ruff, or pope, *Acerina cernua*, which is a small fish with the form of a perch and with conspicuous mucous cavities in the skull. It is common throughout the north of Europe

and especially abundant at the confluence of rivers. *Gymnocephalus schrætzer* of the Danube has the head still more cavernous. *Percarina demidoffi* of southern Russia is another dainty little fish of the general type of the perch. A fossil genus of this type called *Smerdis* is numerously represented in the Miocene and later rocks. The aspron, *Aspro asper*, is a species like a darter found lying on the bottoms of swift rivers, especially the Rhone. The body is elongate, with the paired fins highly developed. *Zingel zingel* is found in the Danube, as is also a third species called *Aspro streber*. In form and coloration these species greatly resemble the American darters, and the genus *Zingel* is, perhaps, the ancestor of the entire group. *Zingel* differs from *Percina* mainly in having seven instead of six branchiostegals and the pseudobranchiæ better

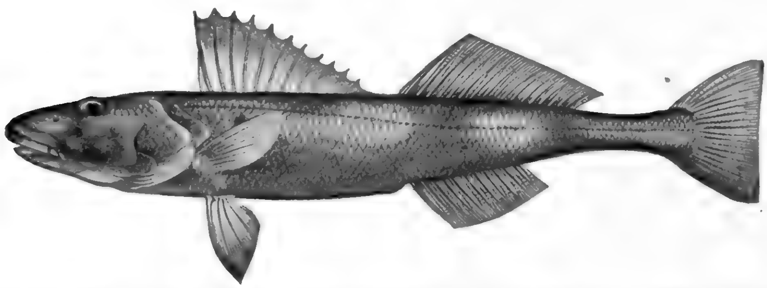


Fig. 243.—The Zingel, *Zingel zingel* (Linnæus). Danube River. (After Seelye.)

developed. The differences in these and other regards which distinguish the darters are features of degradation, and they are also no doubt of relatively recent acquisition. To this fact we may ascribe the difficulty in finding good generic characters within the group. Sharply defined genera occur where the intervening types are lost. The darter is one of the very latest products in the evolution of fishes.

The Darters: Etheostominæ.—Of the darters, or etheostomine perches, over fifty species are known, all confined to the streams of the region bounded by Quebec, Assiniboia, Colorado, and Nuevo Leon. All are small fishes and some of them minute, and some are the most brilliantly colored of all freshwater fishes of any region, the most ornate belonging to the large genus called *Etheostoma*. The largest species, the most primitive because most like the perch, belong to the genus *Percina*.

First among the darters because largest in size, most perch-like in structure, and least degenerate, we place the king darter, *Percina rex* of the Roanoke River in Virginia. This species reaches a length of six inches, is handsomely colored, and looks like a young wall-eye.

The log-perch, *Percina caprodes*, is near to this, but a little smaller, with the body surrounded by black rings alternately

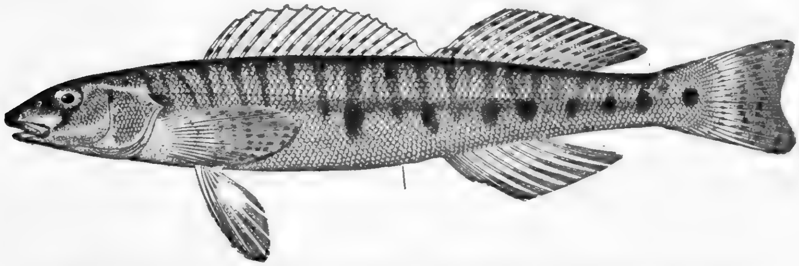


Fig. 244.—Log-perch, *Percina caprodes* (Rafinesque). Licking Co., Ohio.

large and small. In this widely distributed species, large enough to take the hook, the air-bladder is present although small. In the smaller species it vanishes by degrees, and in proportion as in their habits they cling to the bottom of the stream.

The genus *Hadropterus* includes many handsome species, most of them with a black lateral band widened at intervals.

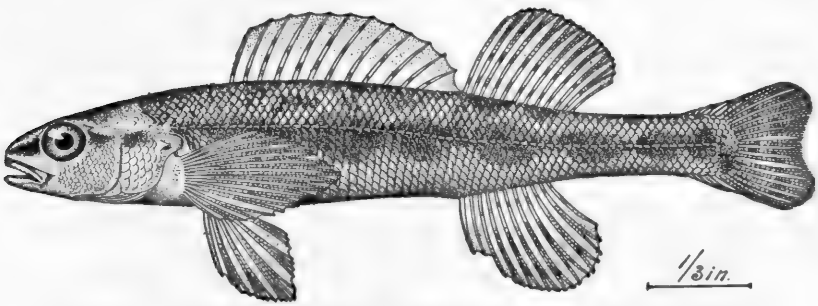


Fig. 245.—Black-sided Darter, *Hadropterus aspro* (Cope & Jordan). Chickamauga River.

The black-sided darter, *Hadropterus aspro*, is the best-known species and one of the most elegant of all fishes, abounding in the clear gravelly streams of the Ohio basin and northwestward.

Hadropterus evides of the Ohio region is still more brilliant,

with alternate bands of dark blue-green and orange-red, most exquisite in their arrangement. In the South, *Hadropterus nigrofasciatus*, the crawl-a-bottom of the Georgia rivers, is a heavily built darter, which Vaillant has considered the ancestral species of the group. Still more swift in movement and bright in color are the species of *Hypohomus*, which flash their showy hues in the sparkling brooks of the Ozark and the Great Smoky Mountains. *Hypohomus aurantiacus* is the best-known species.

Diplesion blennioides, the green-sided darter, is the type of numerous species with short heads, large fins, and coloration

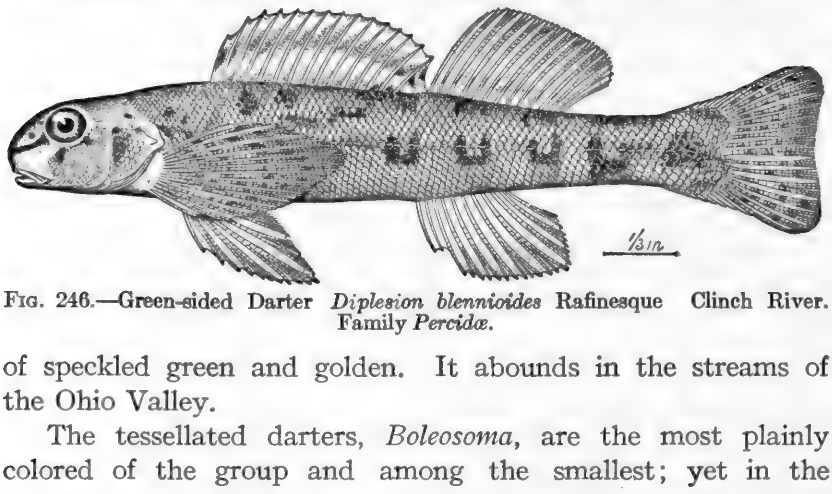


FIG. 246.—Green-sided Darter *Diplesion blennioides* Rafinesque Clinch River. Family *Percidæ*.

of speckled green and golden. It abounds in the streams of the Ohio Valley.

The tessellated darters, *Boleosoma*, are the most plainly colored of the group and among the smallest; yet in the

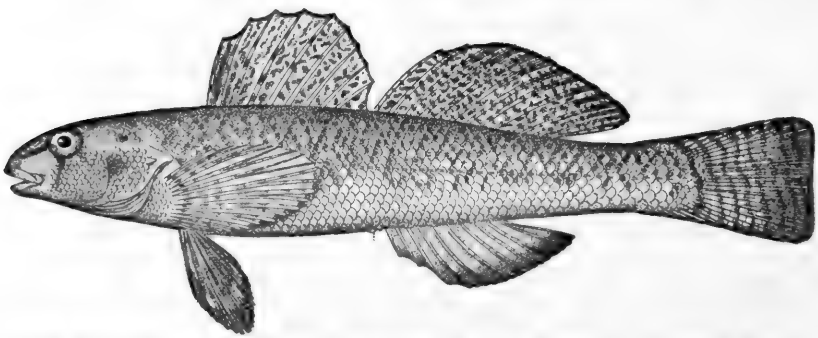


FIG. 247.—Tessellated Darter, *Boleosoma olmstedi* (Storer). Potomac River.

delicacy, wariness, and quaintness of motion they are among the most interesting, especially in the aquarium. *Boleosoma*

nigrum, the Johnny darter in the West, and *Boleosoma olmstedi* in the East are among the commonest species, found half hidden in the weeds of small brooks, and showing no bright colors, although the male in the spring has the head, and often the whole body, jet black.

Crystallaria asprella, a large species almost transparent, is occasionally taken in swift currents along the limestone

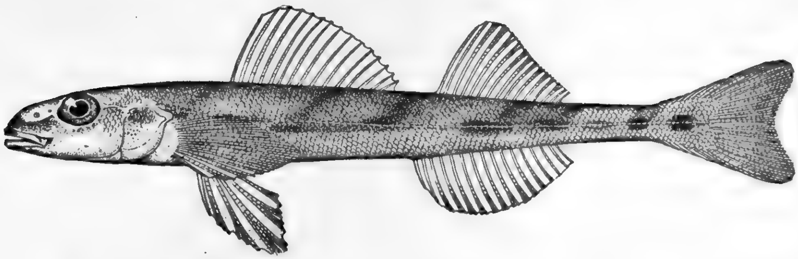


FIG. 248.—Crystal Darter, *Crystallaria asprella* (Jordan). Wabash River.

banks of the Mississippi. Still more transparent is the small sand-darter, *Ammocrypta pellucida*, which lives in the clearest of waters, concealing itself by plunging into the sand. Its scales are scantily developed, as befits a fish that chooses this

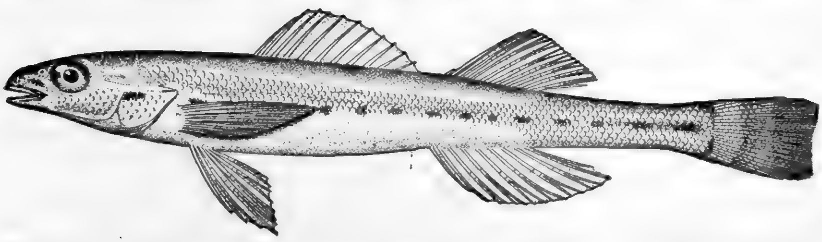


FIG. 249.—Sand-darter, *Ammocrypta clara* (Jordan & Meek). Des Moines River.

method of protection, and in the related *Ammocrypta beani* of the streams of the Louisiana pine-woods, the body is almost naked, as also in *Ioa vitrea*, the glassy darter of the pine-woods of North Carolina.

In the other darters the body is more compressed, the movements less active, the coloration even more brilliant in the males, which are far more showy than their dull olivaceous mates.

To *Etheostoma* nearly half of the species belong, and they

form indeed a royal series of little fishes. Only a few can be noticed here, but all of them are described in detail and many

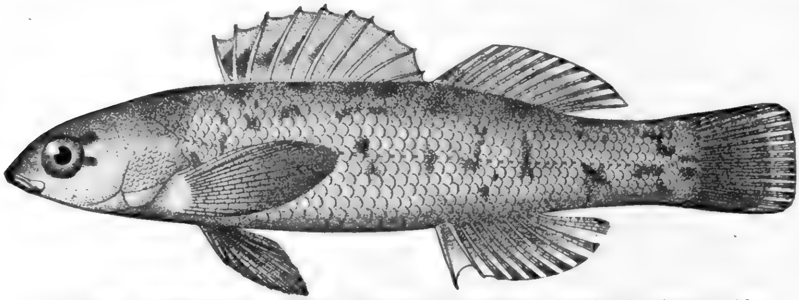


FIG. 250.—*Etheostoma jordani* Gilbert. Chestnut Creek, Verbena, Ala.

are figured by Jordan and Evermann ("Fishes of North and Middle America," Vol. I).

Most beautiful of all fresh-water fishes is the blue-breasted darter, *Etheostoma camurum*, red-blue and olive, with red spots,

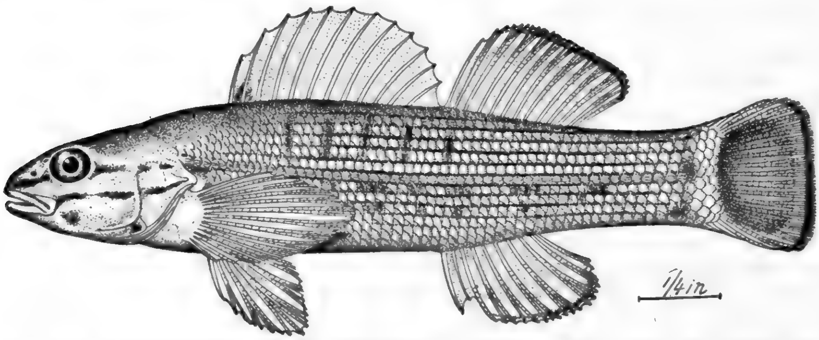


FIG. 251.—Blue-breasted Darter, *Etheostoma camurum* (Cope),the most brilliantly colored of American river fishes. Cumberland Gap, Tenn.

like a trout. This species lives in clear streams of the Ohio valley, a region perhaps to be regarded as the center of abundance of these fishes.

Very similar is the trout-spotted darter, *Etheostoma maculatum*, dusky and red, with round crimson spots. *Etheostoma rufilineatum* of the French Broad is one of the most gaudy of fishes. *Etheostoma australe* of Chihuahua ranges farthest south of all the darters, and *Etheostoma boreale* of Quebec perhaps farthest north, though *Etheostoma iowæ*, found from Iowa to the Saskatchewan, may dispute this honor. *Etheostoma cæruleum*,

the rainbow darter or soldier-fish, with alternate oblique bands of blue and scarlet, is doubtless the most familiar of the brilliantly colored species, as it is the most abundant throughout the Ohio valley.

Etheostoma flabellare, the fan-tailed darter, discovered by Rafinesque in Kentucky in 1817, was the first species of the series made known to science. It has no bright colors, but its movements in water are more active than any of the others, and it is the most hardy in the aquarium.

Psychromaster tuscumbia abounds in the great limestone springs of northern Alabama, while *Copelandellus quiescens* swarms in the black-water brooks which flow into the Dismal Swamp and thence southward to the Suwanee. It is a little fish not very active, its range going farther into the southern lowlands than any other. Finally, *Microperca punctulata*, the least darter, is the smallest of all, with fewest spines and dullest colors, must specialized in the sense of being least primitive, but at the same time the most degraded of all the darters.

No fossil forms nearly allied to the darters are on record. The nearest is perhaps *Mioplosus labracoides* from the Eocene at Green River, Wyoming. This elongate fish, a foot long, has the dorsal rays IX–1, 13, and the anal rays II, 13, its scales finely serrated, and the preopercle coarsely serrated on the lower limb only. This species, with its numerous congeners from the Rocky Mountain Eocene, is nearer the true perch than the darters. Several species related to Perca are also recorded from the Eocene of England and Germany. A species called *Lucioperca skorpili*, allied to *Centropomus*, is described from the Oligocene of Bulgaria, besides several other forms imperfectly preserved, of still more doubtful affinities.

CHAPTER XIX

THE BASS AND THEIR RELATIVES

THE **Cardinal-fishes. Apogonidæ.**—The *Apogonidæ* or cardinal-fishes are perch-like fishes, mostly of small size, with two distinct short dorsal fins. They are found in the warm seas, and many of them enter rivers, some even inhabiting hot springs. Many of the shore species are bright red in color, usually with black stripes, bands, or spots. Still others, however, are olive or silvery, and a few in deeper water are violet-black.

The species of *Apogon* are especially numerous, and in regions where they are abundant, as in Japan, they are much

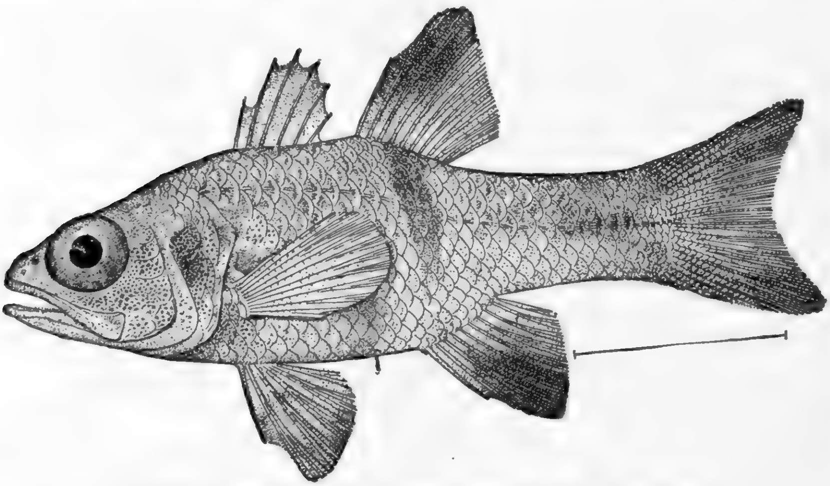


Fig. 252.—Cardinal-fish, *Apogon retrosella* Gill. Mazatlan.

valued as food. *Apogon imberbis*, the "king of the mullet," is a common red species of southern Europe. *Apogon maculatus* is found in the West Indies. *Apogon retrosella* is the pretty "cardenal" of the west coast of Mexico. *Apogon lineatus*,

semilineatus and other species abound in Japan, and many species occur about the islands of Polynesia. *Epigonus telescopium* is a deep-sea fish of the Mediterranean and *Telescopias* and *Synagrops* are genera of the depths of the Pacific. *Paramia* with strong canines is allied to *Apogon*, and similar in color and habit.

Allied to *Apogon* are several small groups often taken as distinct families. The species of *Ambassis* (*Ambassidæ*) are little fishes of the rivers and bays of India and Polynesia, resembling small silvery perch or bass. All these have three anal spines instead of two as in *Apogon*. Some of these enter rivers and several are recorded from hot springs. *Scombrops boops*, the mutsu of Japan, is a valued food-fish found in rather deep water. It is remarkable for its very strong teeth, although its flesh is feeble and easily torn. A still larger species in Cuba, *Scombrops oculata*, known as *Escolar chino*, resembles a barracuda. These fishes with fragile bodies and very strong teeth are placed by Gill in a separate family (*Scombropidæ*). *Acropoma japonicum* is a neat little fish of the Japanese coast, with the vent placed farther forward than in *Apogon*. It is the type of the *Acropomidæ*, a small family of the Pacific. *Enoplosus armatus* is an Australian fish with high back and fins, with a rather stately appearance, type of the *Enoplosidæ*. In his last catalogue of families of fishes Dr. Gill recognizes *Scombropidæ* and *Acropomidæ* as distinct families, but their relationships with *Apogon* are certainly very close. Many genera allied to *Apogon* and *Ambassis* occur in Australian rivers. Several fossils referred to *Apogon* (*Apogon spinosus*, etc.) occur in the Eocene of Italy and Germany.

The Anomalopidæ.—The family of *Anomalopidæ* is a small group of deep-sea fishes of uncertain relationship, but perhaps remotely related to *Apogon*. *Anomalops palpebrata* is found in Polynesia and has beneath the eye a large luminous organ unlike anything seen elsewhere among fishes.

The Asineopidæ. — Another family of doubtful relationship is that of *Asineopidæ*, elsewhere noticed. It is composed of extinct fresh-water fishes found in the Green River shales. In *Asineops squamifrons* the opercles are unarmed, the teeth villiform, and the dorsal fin undivided, composed of eight or

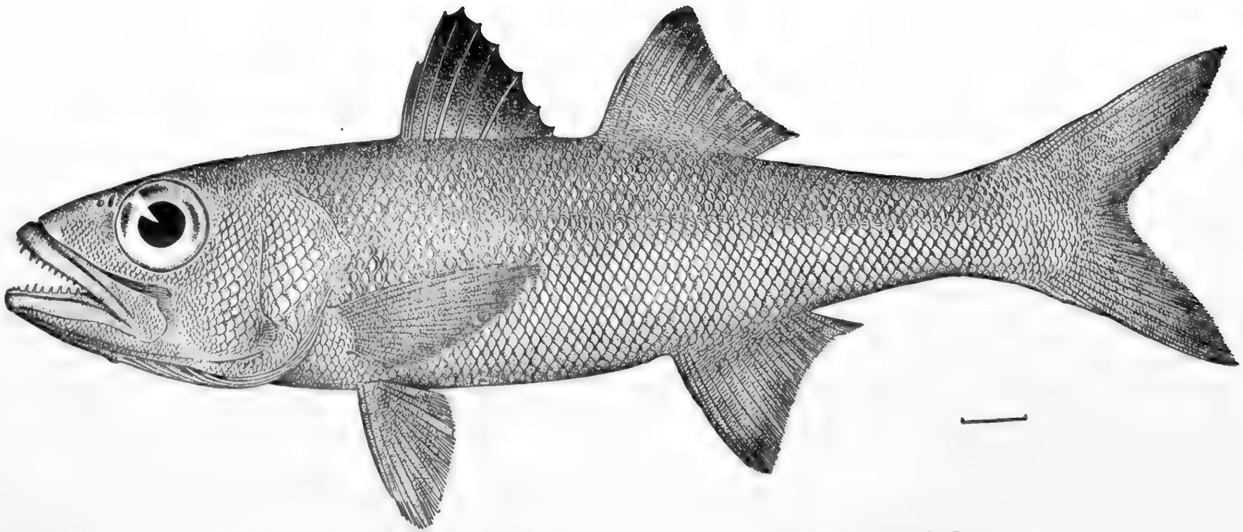


Fig. 253.—Kuromutsu, *Telescopias gilberti* Jordan & Snyder. Misaki, Japan.

nine spines and twelve to fourteen soft rays. The anal spines, as in *Apogon*, are two only, and the scales are cycloid.

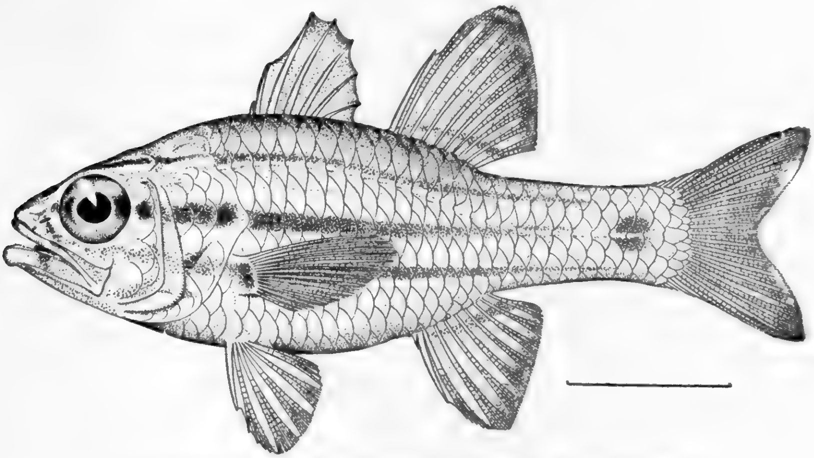


Fig. 254.—*Apogon semilineatus* Schlegel. Misaki, Japan.

The Robalos:* Oxylabracidæ.—The family of Robalos (*Oxylabracidæ* or *Centropomidæ*) is closely related to the *Serranidæ*, differing among other things in having the conspicuous lateral line extended on the caudal fin. These are silvery fishes with

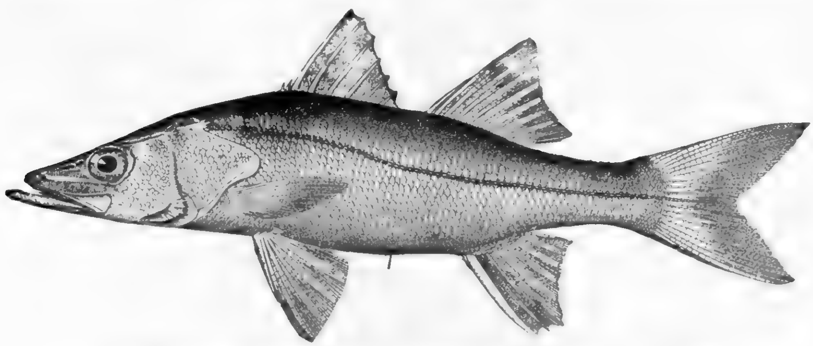


Fig. 255.—Robalo, *Oxylabrax undecimalis* (Bloch). Florida.

elongate bodies, large scales, a pike-like appearance, the first dorsal composed of strong spines and the second spine of the

* The European zander is the type of Lacépède's genus *Centropomus*. The name *Centropomus* has been wrongly transferred to the robalo by most authors.

anal especially large. They are found in tropical America only, where they are highly valued as food, the flesh being like that of the striped bass, white, flaky, and of fine flavor. The common robalo, or snook, *Oxylabrax* (or *Centropomus*) *undecimalis*, reaches a weight of fifteen to twenty pounds. It ranges north as far as Texas. In this species the lateral line is black. The smaller species, of which several are described, are known as *Robalito* or *Constantino*.

The Sea-bass: Serranidæ.—The central family of the percoid fishes is that of the *Serranidæ*, or sea-bass. Of these about 400 species are recorded, carnivorous fishes found in all warm seas, a few ascending the fresh waters. In general, the species are characterized by the presence of twenty-four vertebræ and three anal spines, never more than three. The fresh-water species are all more or less archaic and show traits suggesting the *Oxylabracidæ*, *Percidæ*, or *Centrarchidæ*, all of which are doubtless derived from ancestors of *Serranidæ*. Among the connecting forms are the perch-like genera *Percichthys* and *Percilia* of the rivers of Chile. These species look much like perch, but have three anal spines, the number of vertebræ being thirty-five. *Percichthys trucha* is the common trucha, or trout, of Chilean waters.

Lateolabrax japonicus, the susuki, or bass, of Japan, is one of the most valued food-fishes of the Orient, similar in quality to the robalo, which it much resembles. This genus and the East Indian *Centrogenys waigiensis* approach *Oxylabrax* in appearance and structure. *Niphon spinosus*, the ara of Japan, is a very large sea-bass, also of this type. Close to these bass, marine and fresh water, are the Chinese genus *Siniperca* and the Korean genus *Coreoperca*, several species of which abound in Oriental rivers. In southern Japan is the rare *Bryttosus kawamebari*, a bass in structure, but very closely resembling the American sunfish, even to the presence of the bright-edged black ear-spot. There is reason to believe that from some such form the *Centrarchidæ* were derived.

Other bass-like fishes occur in Egypt (*Lates*), Australia (*Percalates*, etc.), and southern Africa. *Oligorus macquariensis* is the great cod of the Australian rivers and *Ctenolates ambiguus* is the yellow belly, while *Percalates colonorum* is everywhere

the "perch" in Australian rivers. The most important member of these transitional types between perch and sea-bass is the striped bass, or rockfish (*Roccus lineatus*), of the Atlantic coast of the United States. This large fish, reaching in extreme cases a weight of 112 pounds, lives in shallow waters in the sea and ascends the rivers in spring to spawn. It is olivaceous in color, the sides golden silvery, with narrow black stripes. About 1880 it was introduced by the United States Fish Commission into the Sacramento, where it is now very abundant and a fish of large commercial importance. To the angler the striped bass is always "a gallant fish and a bold biter," and Genio Scott places it first among the game-fishes of America.

The white bass (*Roccus chrysops*) is very similar to it, but shorter and more compressed, reaching a smaller size. This fish is abundant in the Great Lakes and the upper Mississippi as far south as Arkansas.

The yellow bass (*Morone interrupta*), a coarser and more brassy fish, replaces it farther south. It is seldom seen above Cincinnati and St. Louis. The white perch (*Morone americana*) is a little fish of the Atlantic seaboard, entering the sea, but running up all the rivers, remaining contentedly landlocked in ponds. It is one of the most characteristic fishes of the coast from Nova Scotia to Virginia. It is a good pan fish, takes the hook vigorously, and in a modest way deserves the good-will of the angler who cannot stray far into the mountains. Very close to these American bass is the bass, bars, or robalo, of southern Europe, *Dicentrarchus labrax*, a large olive-colored fish, excellent as food, living in the sea about the mouths of rivers.

The Jewfishes.—In the warm seas are certain bass of immense size, reaching a length of six feet or more, and being robust in form, a weight of 500 or 600 pounds. These are dusky green in color, thick-headed, rough-scaled, with low fins, voracious disposition, and sluggish movements. In almost all parts of the world these great bass are called jewfish, but no reason for this name has ever been suggested. In habit and value the species are much alike, and the jewfish of California, *Stereolepis gigas*, the prize of the Santa Catalina anglers, may be taken as the type of them all. Closely related

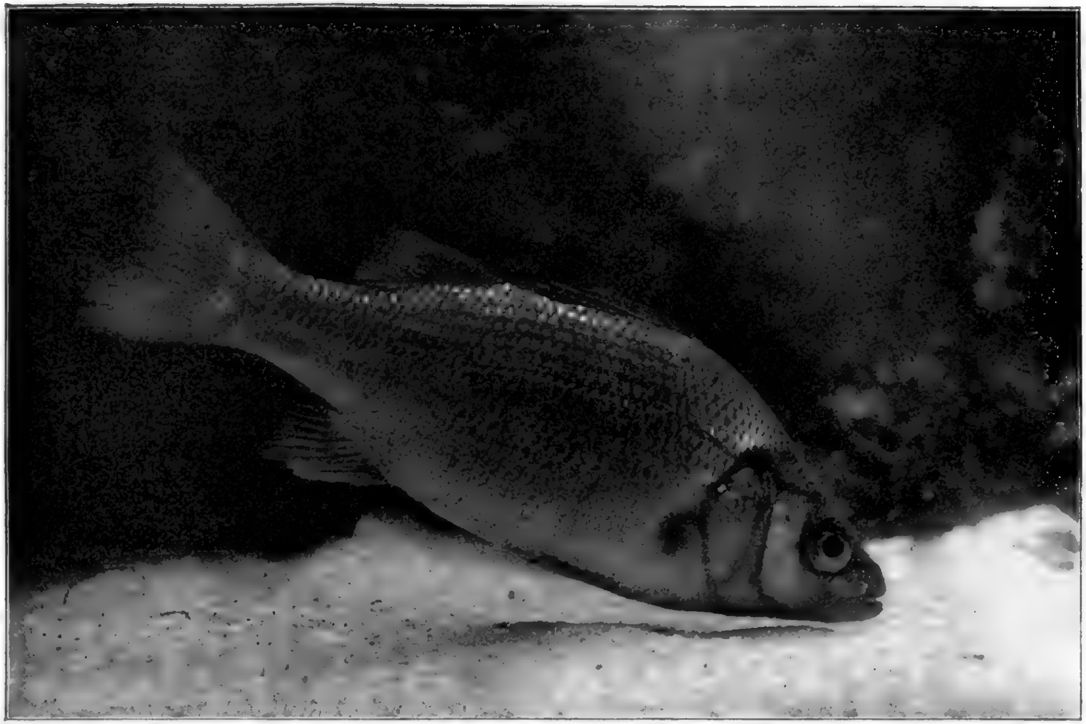


FIG. 256.—White Perch, *Morone americana* Gmelin. (From life by Dr. R. W. Shufeldt; one half natural size.)

to this is the Japanese ishinagi, *Megaperca ischinagi*, the jewfish, or stone-bass, of Japan. Another Japanese jewfish is the Abura bodzu, or "fat priest," *Ebisus sagamius.* In the West Indies, as also on the west coast of Mexico, the jewfish, or guasa, is *Promicrops itaiara.* The black grouper, *Garrupa nigrita*, is the jewfish of Florida. The European jewfish, more often called wreckfish, or stone-bass, is *Polyprion americanus*, and the equally large *Polyprion oxygeneios* is found in Australia, as is also another jewfish, *Glaucosoma hebraicum*, the last belonging to the *Lutianidæ.* Largest of all these jewfishes is *Promicrops lanceolata* of the South Pacific. This huge bass,

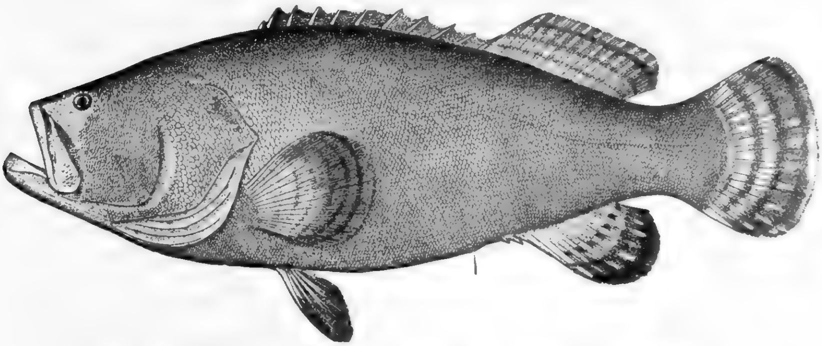


Fig. 257.—Florida Jewfish, *Promicrops itaiara* (Lichtenstein). St. John's River, Fla.

according to Dr. Boulenger, sometimes reaches a length of twelve feet.

Related to the jewfishes are numerous smaller fishes. One of these, the Spanish-flag of Cuba, *Gonioplectrus hispanus*, is rose-colored, with golden bands like the flag of Spain itself. Other species referred to *Acanthistius* and *Plectropoma* have, like this, hooked spines on the lower border of the preopercle.

The Groupers.—In all warm seas abound species of *Epinephelus* and related genera, known as sea-bass, groupers, or merous. They are mostly large voracious fishes with small scales, pale flesh of fair quality, and from their abundance they are of large commercial importance. To English-speaking people these fishes are usually known as grouper, a corruption of the Portuguese name garrupa. In the West Indies and about Panama there are very many species, and still others abound in the Mediter-

ranean, in southern Japan, and throughout Polynesia and the West Indies. They have very much in common, but differ in size and color, some being bright red, some gaudily spotted with red or blue, but most of them are merely mottled green or brown. In many cases individuals living near shore are olivaceous, and those of the same species in the depths are bright crimson or scarlet. We name below a few of the most prominent species. Even a bare list of all of them would take

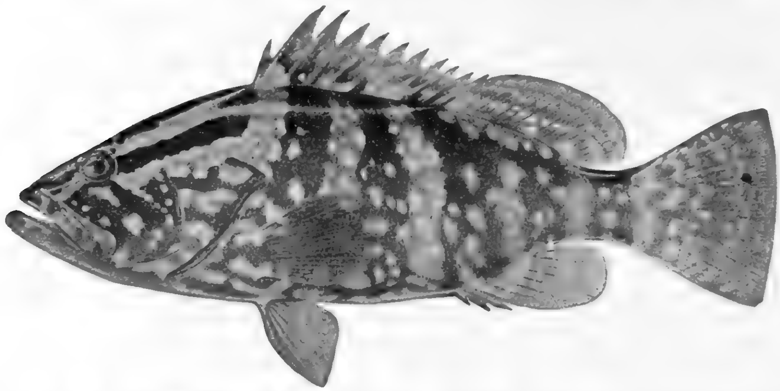


FIG. 258.—*Epinephelus striatus* (Bloch), Nassau Grouper: *Cherna criolla.* Family *Serranidæ.*

many pages. *Cephalopholis cruentatus*, the red hind of the Florida Keys, is one of the smallest and brightest of all of them. *Cephalopholis fulvus*, the blue-spotted guativere of the Cubans, is called negro-fish, butter-fish, yellow-fish, or redfish, according to its color, which varies with the depth. It is red, yellow, or olive, with many round blue spots. *Epinephelus adscenscionis*, the rock-hind, is spotted everywhere with orange. *Epinephelus guaza* is the merou, or giant-bass, of Europe, a large food-fish of value, rather dull in color. *Epinephelus striatus* is the Nassau grouper, or *Cherna criolla*, common in the West Indies. *Epinephelus maculosus* is the cabrilla of Cuba. *Epinephelus drummond-hayi*, the speckled hind, umber brown, spotted with lavender, is one of the handsomest of all the groupers. *Epinephelus morio*, the red grouper, is the commonest of all these fishes in the American markets. In Asia the species are equally numerous, *Epinephelus quernus* of Hawaii and the red *Epinephelus fasciatus* of Japan and southward being food-

fishes of importance. *Epinephelus merra*, *Epinephelus gilberti*, and *Epinephelus tauvina* are among the more common species of Polynesia. *Epinephelus corallicola*, a species profusely

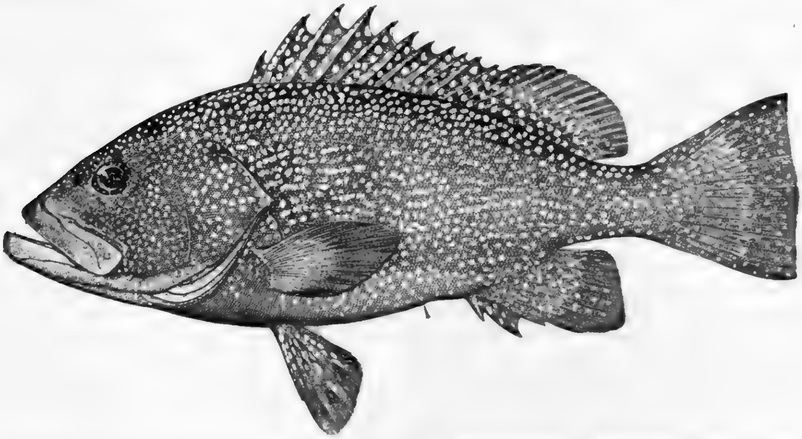


Fig. 259.—John Paw or Speckled Hind, *Epinephelus drummond-hayi* Goode Pensacola.

spotted, abounds in the crevices of corai reefs, while *Cephalopholis argus* and *C. leopardus* are showy fishes of the deeper channels. *Mycteroperca venenosa*, the yellow-finned grouper, is a large and handsome fish of the coast of Cuba, the flesh sometimes poisonous; when red in deep water it is known as

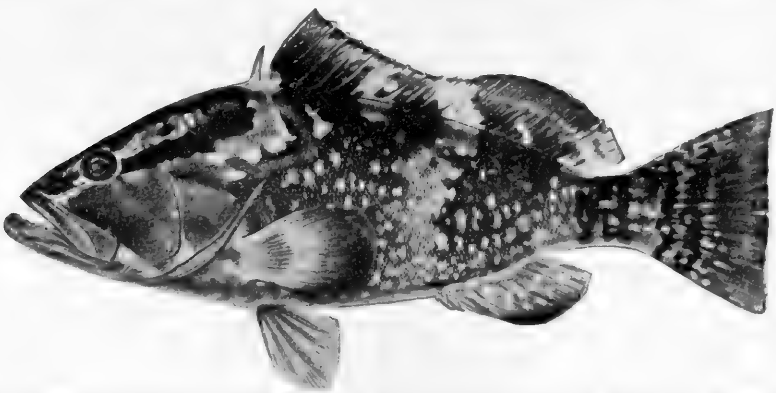


Fig. 260.—*Epinephelus morio* (Cuvier & Valenciennes), Red Grouper, or Mero. Family *Serranidæ*

the bonaci cardenal. *Mycteroperca bonaci;* the bonaci arara sells in our markets as black grouper. *Mycteroperca microlepis*

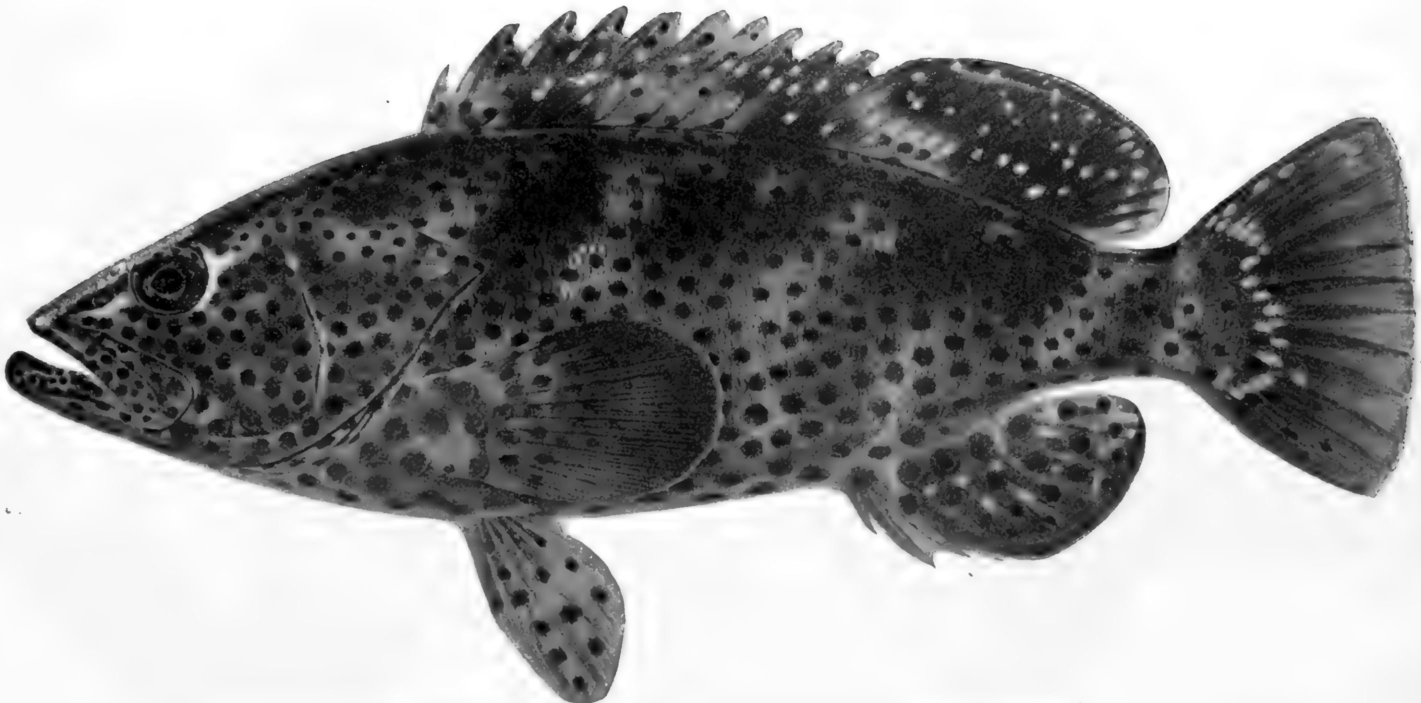


FIG. 261.—Red Hind, *Epinephelus adscensionis* (Osbeck). Puerto Rico. (After Evermann.)

is commonest along our South Atlantic coast, not reaching the West Indies, and *Mycteroperca rubra*, which is never red, enters the Mediterranean. *Mycteroperca falcata* is known in the markets as scamp, and *Mycteroperca venadorum* is a giant species from the Venados Islands, near Mazatlan. *Diplobrion bifasciatus* is a handsome grouper-like fish with two black cross-bands, found in Japan and India. *Variola louti*, red, with crimson spots and a forked caudal fin, is one of the most showy fishes of the equatorial Pacific.

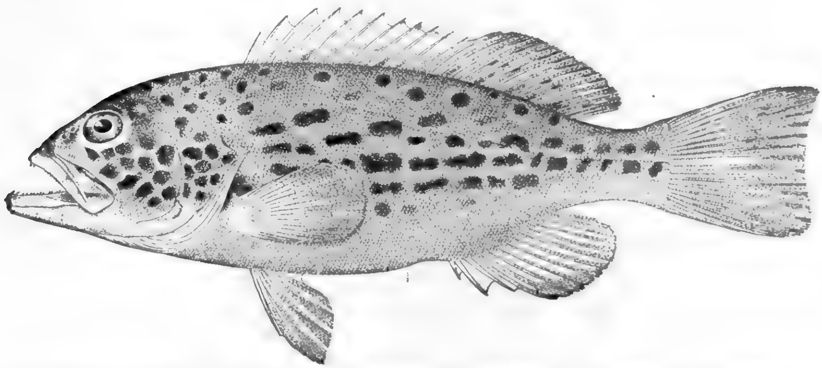


Fig. 262.—Yellow-fin Grouper, *Mycteroperca venenosa* (Linnæus). Havana.

The small fishes called Vaca in Cuba belong to the genus *Hypoplectrus*. Their extraordinary and unexplained variations in color have been noticed on page 235, Vol. I. The common species—blue, orange, green, plain, striated, checkered, or striped —bears the name of *Hypoplectrus unicolor*. (Fig. 264).

The Serranos.—In all the species known as jewfish and grouper, as also in the *Oxylabracidæ* and most *Centrarchidæ*, the maxillary bone is divided by a lengthwise suture which sets off a distinct supplemental maxillary. This bone is wanting in the remaining species of *Serranidæ*, as it is also in those forms already noticed which are familiarly known as bass. The species without the supplemental maxillary are in general smaller in size, the canines are on the sides of the jaws instead of in front, and there are none of the hinged depressible teeth which are conspicuous in the groupers. The species are abundant in the Atlantic, but scarcely any are found in Polynesia, and few in Japan or India.

Serranus cabrilla is the Cabrilla of the Mediterranean, a well-known and excellent food-fish, the original type of the family of *Serranidæ*. *Serranellus scriba* is the serran, a very pretty shore-fish of southern Europe, longer known than any other of the tribe. On the coast of southern California are also species called Cabrillas, fine, large, food-fish, bass-like in form, *Paralabrax clathratus*, and other less common species. The *Cabrillas* and their relatives are almost all American, a few straying across to Europe. One of the most important in the number is the black sea-bass, or black will, of our Atlantic

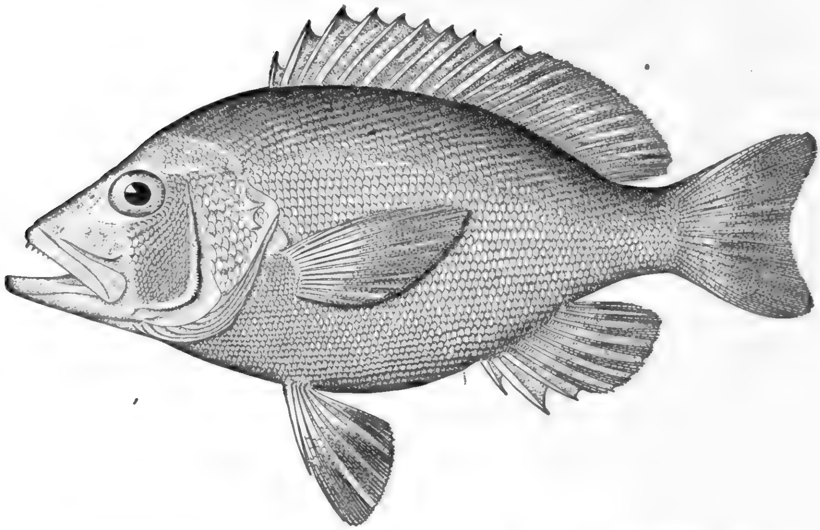


FIG. 263.—*Hypoplectrus unicolor nigricans* (Poey). Tortugas, Fla.

coast, *Centropristes striatus*. This is a common food- and game-fish, dusky in color, gamy, and of fine flesh. The squirrel-fishes (*Diplectrum*) and the many serranos (*Prionodes*) of the tropics, small bright-colored fishes of the rocks and reefs, must be passed with a word, as also the small *Paracentropristis* of the Mediterranean and the fine red creole-fish of the West Indies, *Paranthias furcifer*. In one species, *Anyperodon leucogrammicus* of Polynesia, there are no teeth on the palatines.

The barber-fish (*Anthias anthias*) of southern Europe, bright red and with the lateral line running very high, is the type of a numerous group found at the lowest fishing level in all warm seas. All the species of this group are bright red, very hand-

FIG. 264.—Snowy Grouper, *Epinephelus niveatus* (Cuv. & Val.). Natural size: young. (Photograph by Dr. R. W. Shufeldt.)

some, and excellent as food. *Hemianthias vivanus*, known only from the spewings of the red snapper (*Lutianus aya*) at Pensacola, is one of the most brilliant species, red, with golden streaks. The genus *Plesiops* consists of small fishes almost black in color, with blue spots and other markings, abounding about the coral reefs. In this genus the lateral line is interrupted and there is some indication of affinity with the *Opisthognathidæ*.

In the soapfishes (*Rypticus*) the supplementa lmaxillary appears again, but in these forms the dorsal fin is reduced to two or three spines and there are none in the anal. *Rypticus saponaceus*, so called from the smooth or soapy scales, is the

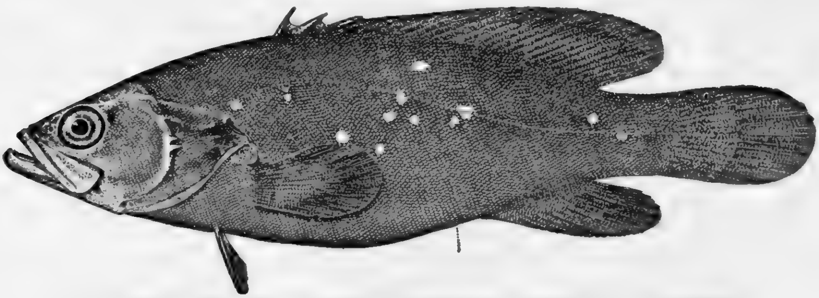


FIG. 265.—Soapfish, *Rypticus bistrispinus* (Mitchill). Virginia.

best known of the numerous species, which all belong to tropical America. *Grammistes*, with eight dorsal spines, is a related form in Polynesia, bright yellow, with numerous black stripes. Numerous species referred to the *Serranidæ* occur in the Eocene and Miocene rocks. Some are related to *Epinephelus*, others to *Roccus* and *Lates*. In the Tertiary lignite of Brazil is a species of *Percichthys*, *Percichthys antiquus*, with *Properca beaumonti*, which seem to be a primitive form of the bass, allied to *Dicentrarchus*. *Prolates heberti* of the Cretaceous, one of the earliest of the series, has the caudal rounded and is apparently allied to *Lates*, as is also the heavily armed *Acanus regleysianus* of the Oligocene. *Smerdis minutus*, a small fish from the Oligocene, is also related to *Lates*, which genus with *Roccus* and *Dicentrarchus* must represent the most primitive of existing members of this family. Of both *Smerdis* and *Dicentrarchus* (*Labrax*) numerous species are recorded, mostly from the Miocene of Europe.

The Flashers: Lobotidæ.—The small family of *Lobotidæ*, flashers, or triple-tails, closely resembles the *Serranidæ*, but there

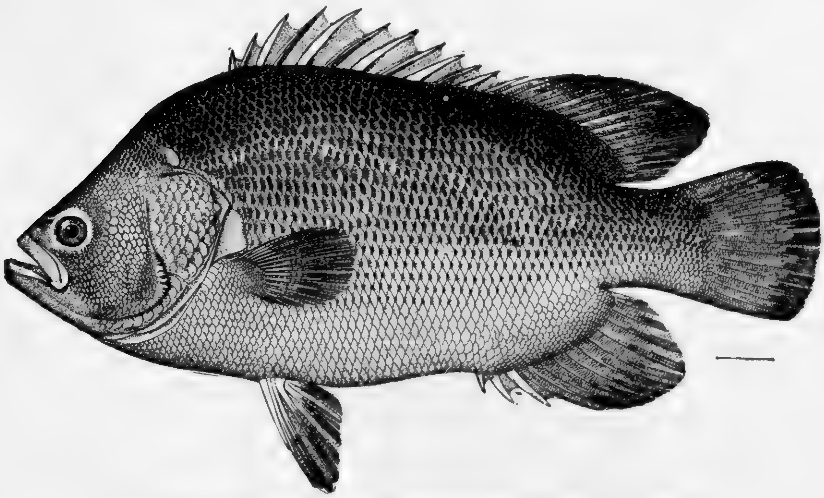


FIG. 266.—Flasher, *Lobotes surinamensis* (Bloch). Virginia.

are no teeth on vomer or palatines. The three species are robust fishes, of a large size, of a dark-green color, the front part of the head very short. They reach a length of about

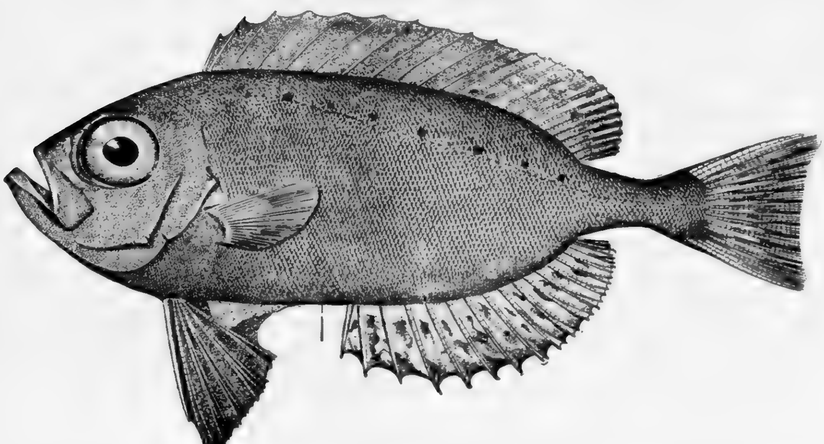


FIG. 267.—Catalufa, *Priacanthus arenatus* Cuv. & Val. Wood's Hole, Mass.

three feet and are good food-fishes. *Lobotes surinamensis* comes northward from the West Indies as far as Cape Cod.

FIG. 268.—Bigeye, *Pseudopriacanthus altus* Gill. Young specimen. (From life by Dr. R. W. Shufeldt.)

Lobotes pacificus is found about Panama. *Lobotes erate*, common in India, was taken by the writer at Misaki, Japan.

The Bigeyes: Priacanthidæ.—The *Catalufas* or bigeyes (*Priacanthidæ*) are handsome fishes of the tropics, with short, flattened bodies, rough scales, large eyes, and bright-red coloration. The mouth is very oblique, and the anal fin about as large as the dorsal. The commonest species is *Priacanthus cruentatus*, widely diffused through the Pacific and also in the West Indies. This is the noted Aweoweo of the Hawaiians, which used to come into the bays in myriads at the period of death of royalty. It is still abundant, even after Hawaiian royalty has passed away.

Pseudopriacanthus altus is a short, very deep-bodied, and very rough fish, scarlet in color, occasionally taken along our coast, driven northward by the Gulf Stream. The young fishes are quite unlike the adult in appearance. Numerous other species of *Priacanthus* occur in the Indies and Polynesia.

The Pentacerotidæ. — Another family with strong spines and rough scales is the group of *Pentacerotidæ*. *Histiopterus typus*, the Matodai, is found in Japan, and is remarkable for its very deep body and very high spines. Equally remarkable is the Tengudai, *Histiopterus acutirostris*, also Japanese. *Anoplus banjos* is a third Japanese species, more common than the others, and largely taken in the Inland Sea. All these are eccentric variations from the perch-like type.

The Snappers: Lutianidæ.—Scarcely less numerous and varied than the sea-bass is the great family of *Lutianidæ*, known in America as snappers or pargos. In these fishes the maxillary slips along its edge into a sheath formed by the broad preorbital. In the *Serranidæ* there is no such sheath. In the *Lutianidæ* there is no supplemental maxillary, teeth are present on the vomer and palatines, and in the jaws there are distinct canines. These fishes of the warm seas are all carnivorous, voracious, gamy, excellent as food though seldom of fine grain, the flesh being white and not flaky. About 250 species are known, and in all warm seas they are abundant.

To the great genus *Lutianus* most of the species belong. These are the snappers of our markets and the pargos of the Spanish-speaking fishermen. The shore species are green in color, mostly

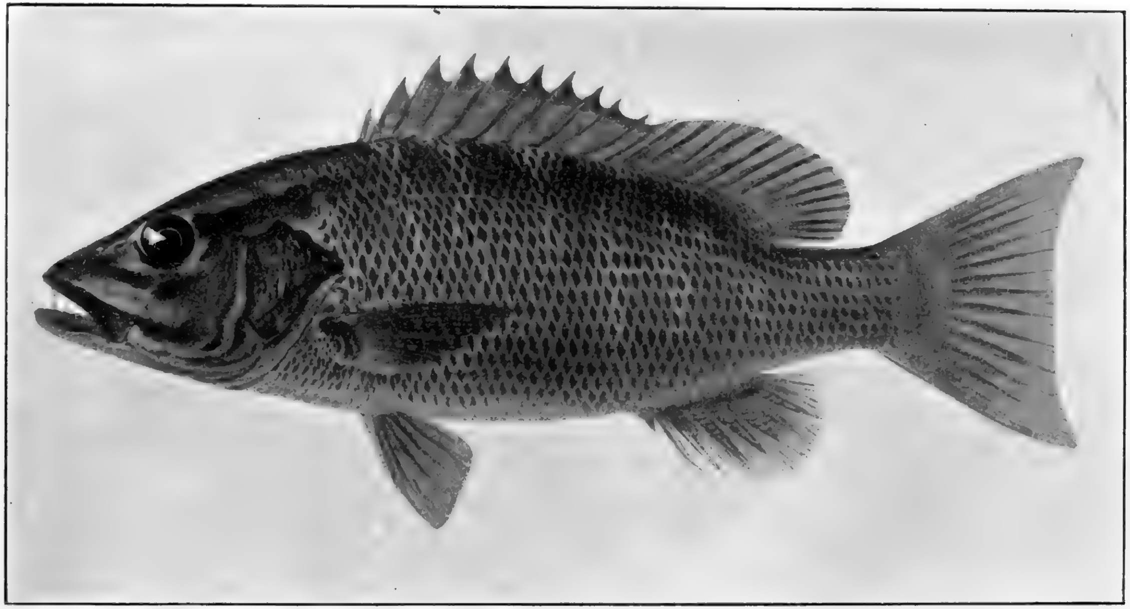


Fig. 269.—Gray Snapper, *Lutianus griseus* L. Puerto Rico. (After Evermann.)

banded, spotted, or streaked. In deeper water bright-red species are found. One of these, *Lutianus aya*, the red snapper or pargo guachinango of the Gulf of Mexico, is, economically speaking, the most important of all these fishes in the United States. It is a large, rather coarse fish, bright red in color, and it is taken on long lines on rocky reefs chiefly about Pensacola and Tampa in Florida, although similar fisheries exist on the shores of Yucatan and Brazil.

A related species is the *Lutianus analis*, the mutton snapper or pargo criollo of the West Indies. This is one of the staple

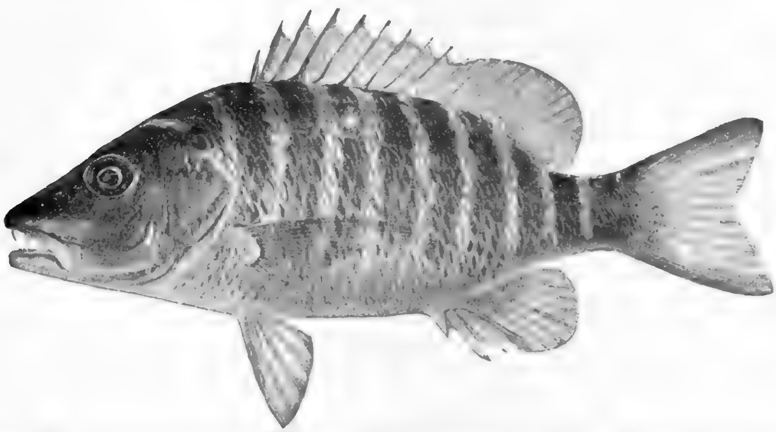


Fig. 270.—*Lutianus apodus* (Walbaum), Schoolmaster or Cají. Family *Lutianidæ*.

fishes of the Havana market, always in demand for banquets and festivals, because its flesh is never unwholesome. The mangrove snapper, or gray-snapper, *Lutianus griseus*, called in Cuba, Caballerote, is the commonest species on our coasts. The common name arises from the fact that the young hide in the mangrove bushes of Florida and Cuba, whence they sally out in pursuit of sardines and other small fishes. It is a very wary fish, to be sought with care, hence the name "lawyer," sometimes heard in Florida. The cubero (*Lutianus cyanopterus*) is a very large snapper, often rejected as unwholesome, being said to cause the disease known as ciguatera. Certain snappers in Polynesia have a similar reputation. The large red mumea, *Lutianus bohar*, is regarded as always poisonous in Samoa—the most dangerous fish of the islands. *L. leioglossus* is

also held under suspicion on Tutuila, though other fishes of this type are regarded as always safe. Other common snappers

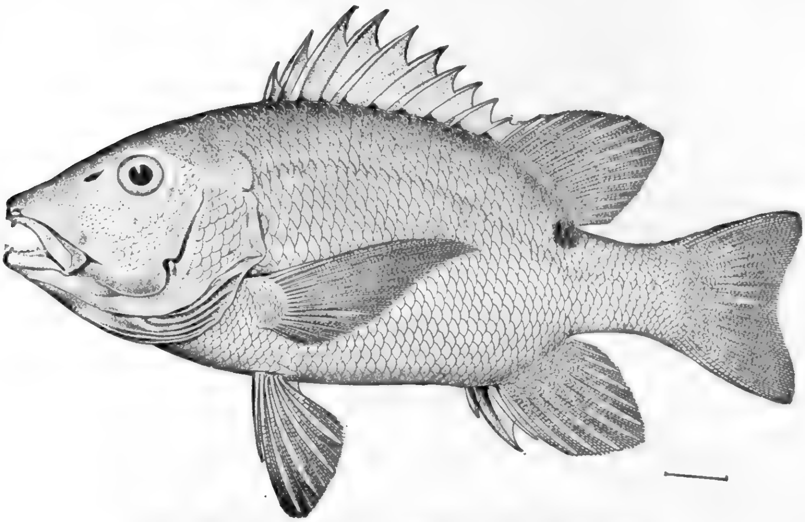


FIG. 271.—*Hoplopagrus guntheri* Gill. Mazatlan.

of Florida and Cuba are the dog snapper or jocú (*Lutianus jocu*), the schoolmaster or cají (*Lutianus apodus*), the black-fin snapper or sese de lo alto (*Lutianus buccanella*), the silk snapper or

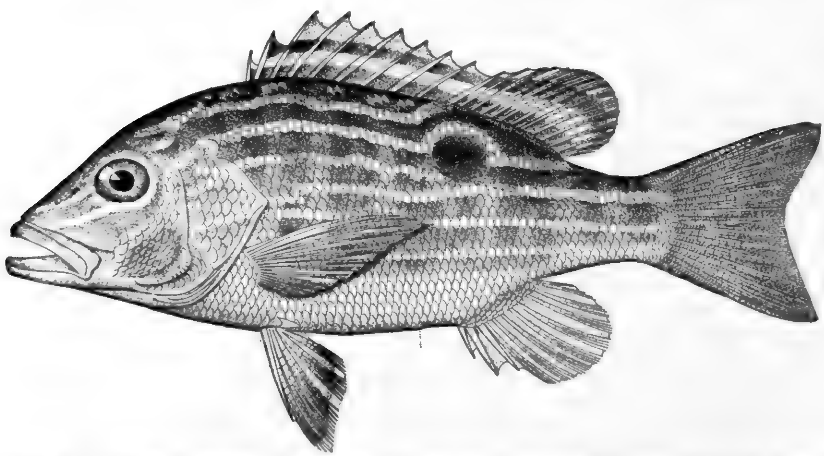


FIG. 272.—Lane Snapper or Biajaiba, *Lutianus synagris* (Linnæus). Key West.

pargo de lo alto (*Lutianus vivanus*), the abundant lane snapper or biajaiba (*Lutianus synagris*), and the mahogany snapper

or ojanco (*Lutianus mahogani*). Numerous other species occur on both coasts of tropical America, and a vastly larger assemblage is found in the East Indies, some of them ranging northward to Japan.

Hoplopagrus güntheri is a large snapper of the west coast of Mexico, having very large molar teeth in its jaws besides slit-

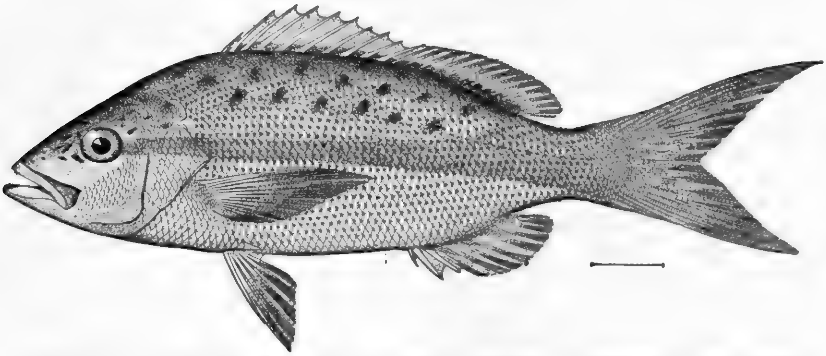


Fig. 273.—Yellow-tail Snapper, *Ocyurus chrysurus* (Linnæus). Key West.

like nostrils and other notable peculiarities. From the standpoint of structure this species, with its eccentric characters—is especially interesting. The yellow-tail snapper or rabirubia (*Ocyurus chrysurus*) is a handsome and common fish of the

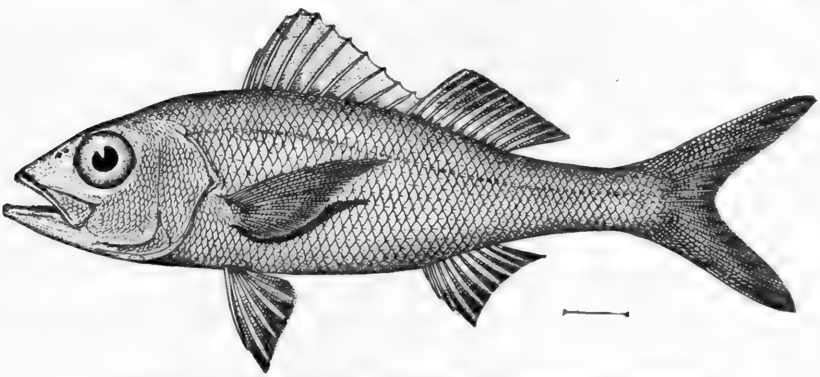


Fig. 274.—Cachucho, *Etelis oculatus* (Linnæus). Havana.

West Indies, with long, deeply forked tail, which makes it a swifter fish than the others. Another red species is the diamond snapper or cagon de lo alto, *Rhomboplites aurorubens*. All these true snappers have the soft fins more or less scaly.

In certain species that swim more freely in deep waters; these fins are naked. Among them is the Arnillo, *Apsilus dentatus*, a pretty brown fish of the West Indies, and its a nalogue in Hawaii, *Apsilus brighami*, red, with golden cross-bands. *Aprion virescens*, the Uku of Hawaii, is a large fish of a greenish colorand elongate body, widely diffused throughout Polynesia andone of the best of food-fishes. A related species is the red voraz (*Aprion macrophthalmus*) of the West Indies.

Most beautiful of all the group are the species of *Etelis*, with the dorsal fin deeply divided and the head flattened above. These live in rather deep water about rocky reefs and are fiery red in color. Best known is the Cuban species, *Etelis oculatus*, the cachucho of the markets. Equally abundant and equally

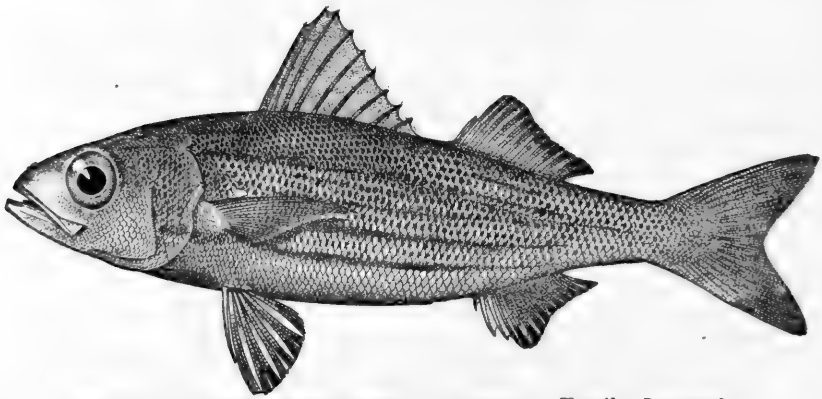


FIG. 275.—*Xenocys jessiæ* Jordan & Bollman. Family *Lutianidæ*. Galapagos Islands.

beautiful is *Etelis carbunculus* of Polynesia, *Etelis evurus* of Hawaii, and other species of the Pacific islands.

Verilus sordidus, the black escolar of Cuba, has the form of *Etelis*, but the flesh is very soft and the color violet-black, indicating its life in very deep water. Numerous small silvery snappers living near the shore along the coast of western Mexico belong to the genera called *Xenichthys*, *Xenistius*, and *Xenocys*. *Xenistius californiensis* is the commonest of these species, *Xenocys jessiæ*, the largest in size, with black lines like a striped bass. To the genus *Dentex* belongs a large snapper-like fish of

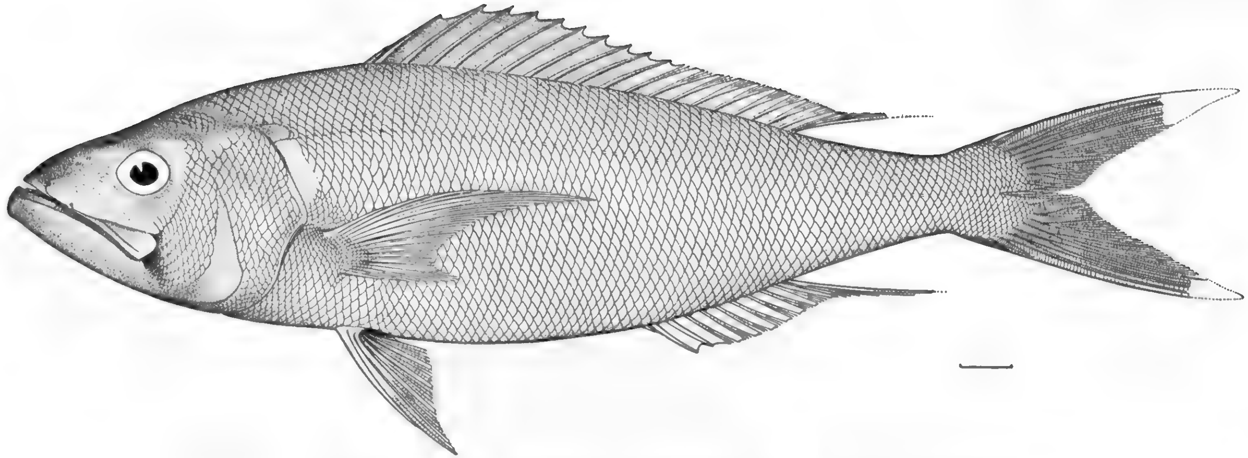


FIG. 276.—*Aphareus furcatus* (Lacépède). Odawara, Japan. Family *Lutianidæ*.

the Mediterranean, *Dentex dentex.* Very many related species occur in the old world, the prettily colored *Nemipterus virgatus*, the *Itoyori* of Japan being one of the best known. Another interesting fish is *Aphareus furcatus*, a handsome, swift fish of the open seas occasionally taken in Japan and the East Indies. *Glaucosoma burgeri* is a large snapper of Japan, and a related species, *Glaucosoma hebraicum*, is one of the "jewfishes" of Australia. Numerous fossil forms referred to *Dentex* occur in the Eocene of Monte Bolca, as also a fish called *Ctenodentex lackeniensis* from the Eocene of Belgium.

The Grunts: Hæmulidæ.—The large family of *Hæmulidæ*, known in America as grunters or roncos, is represented with the

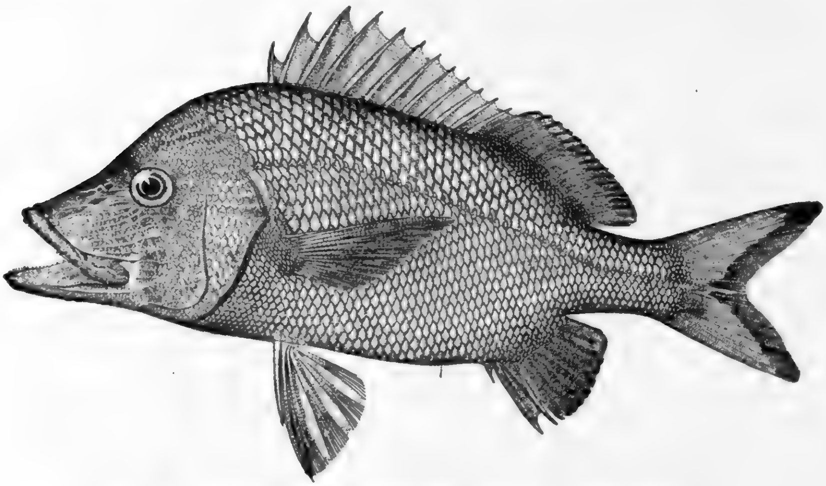


Fig. 277.—Grunt, *Hæmulon plumieri* (Bloch). Charleston, S. C.

snappers in all tropical seas. The common names (Spanish, *roncar*, to grunt or snore) refer to the noise made either with their large pharyngeal teeth or with the complex air-bladder. These fishes differ from the *Lutianinæ* mainly in the feebler detention, there being no canines and no teeth on the vomer. Most of the American species belong to the genus *Hæmulon* or red-mouth grunts, so called from the dash of scarlet at the corner of the mouth. *Hæmulon plumieri*, the common grunt, or ronco arará, is the most abundant species, known by the narrow blue stripes across the head. In the yellow grunt, ronco amarillo (*Hæmulon sciurus*), these stripes cross the whole

body. In the margate-fish, or Jallao (*Hæmulon album*), the largest of the grunts, there are no stripes at all. Another common grunt is the black spotted sailor's choice, *Ronco prieto* (*Hæmulon parra*), very abundant from Florida southward. Numerous other grunts and "Tom Tates" are found on both shores of Mexico, all the species of *Hæmulon* being confined to America. *Anisotremus* includes numerous deep-bodied species with smaller mouth, also all American. *Anisotremus surinamensis*, the pompon, abundant from Louisiana southward is the commonest species. *Anisotremus virginicus*, the porkfish or Catalineta,

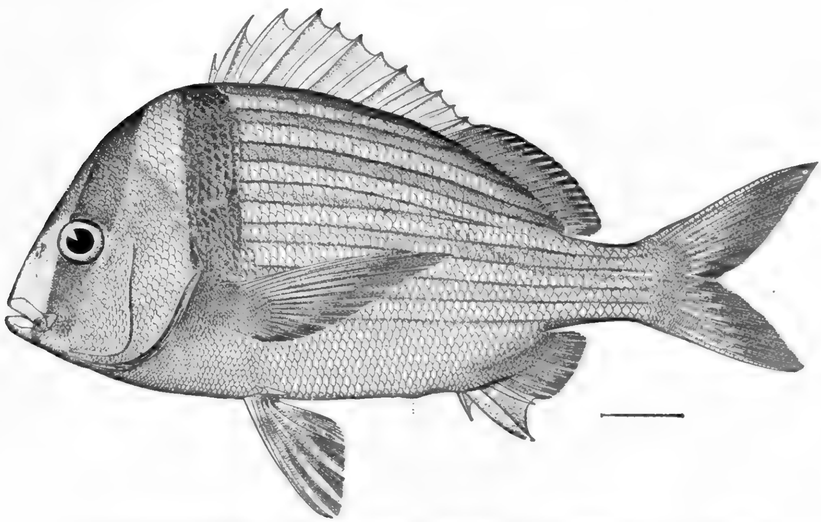


FIG. 278.—Porkfish, *Anisotremus virginicus* (Linnæus). Key West.

beautifully striped with black and golden, is very common in the West Indies. *Plectorhynchus* of Polynesia and the coasts of Asia contains numerous large species closely resembling *Anisotremus*, but lacking the groove at the chin characteristic of *Anisotremus* and *Hæmulon*. Some of these are striped or spotted with black in very gaudy fashion. *Pomadasis*, a genus equally abundant in Asia and America, contains silvery species of the sandy shores, with the body more elongate and the spines generally stronger. *Pomadasis crocro* is the commonest West Indian species, *Pomadasis hasta* the best known of the Asiatic forms. *Gnathodentex aurolineatus* with golden stripes is common in Polynesia.

The pigfishes, *Orthopristis*, have the spines feebler and the anal fin more elongate. Of the many species, American and Mediterranean, *Orthopristis chrysopterus* is most familiar, ranging northward to Long Island, and excellent as a pan fish. *Parapristipoma trilineatum*, the Isaki of Japan, is equally abundant and very similar to it. Many related species belong to the Asiatic genera, *Terapon*, *Scolopsis*, *Cæsio*, etc., sometimes placed in a distinct family as *Teraponidæ*. *Terapon servus* enters the streams of Polynesia, and is a very common fish of the river mouths, taken in Samoa by the boys. *Terapon theraps* is found throughout the East Indies. *Terapon richardsoni* is the Australian silver perch. *Cæsio* contains numerous small species, elongate and brightly colored, largely blue and golden. *Scolopsis*, having a spine on the preorbital, contains numerous species in the East Indies and Polynesia. These are often handsomely colored. Among them is the taiva, *Scolopsis trilineatus* of Samoa, gray with white streaks and markings of delicate pattern. A fossil species in the Italian Eocene related to *Pomadasis* is *Pomadasis furcatus*. Another, perhaps allied to *Terapon*, is called *Pelates quindecimalis*.

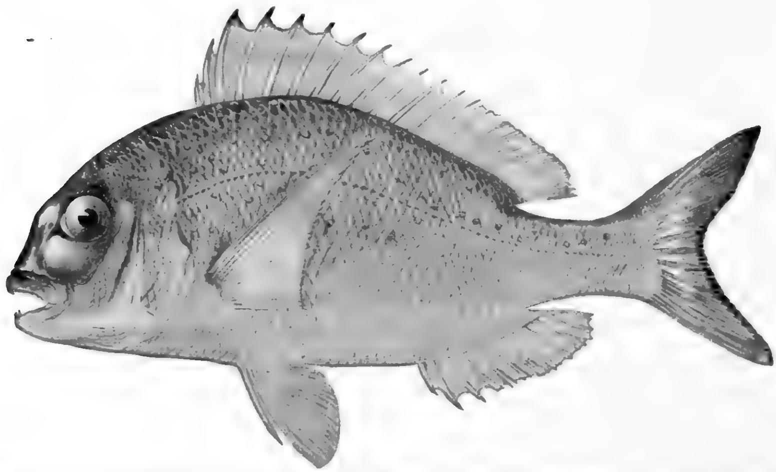


Fig. 279.—The Red Tai of Japan, *Pagrus major* Schlegel. Family *Sparidæ*. (After Kishinouye.)

The Porgies: Sparidæ.—The great family of *Sparidæ* or porgies is also closely related to the *Hæmulidæ*. The most tangible difference rests in the teeth, which are stronger, and

some of those along the side of the jaw are transformed into large blunt molars, fitted for grinding small crabs and shells. The name porgy, in Spanish pargo, comes from the Latin *Pagrus* and Greek πάγρος, the name from time immemorial of the red porgy of the Mediterranean, *Pagrus pagrus*. In this

FIG. 280.—Ebisu, the Fish-god of Japan, bearing a Red Tai (Sketch by Kako Morita.)

species the front teeth are canine-like, the side teeth molar. It is a fine food-fish, very handsome, being crimson with blue spots, and in the Mediterranean it is much esteemed. It also breeds sparingly on our south Atlantic and Gulf coasts.

Very similar to the porgy is the famous red tai or akadai of Japan (*Pagrus major*), a fish so highly esteemed as to be, with the rising sun and the chrysanthemum, a sort of national emblem. In all prints and images the fish-god Ebisu (Fig. 280), beloved of the Japanese people, appears with a red tai under his arm. This species, everywhere abundant, is crimson in color, and the flesh is always tender and excellent. A similar species is

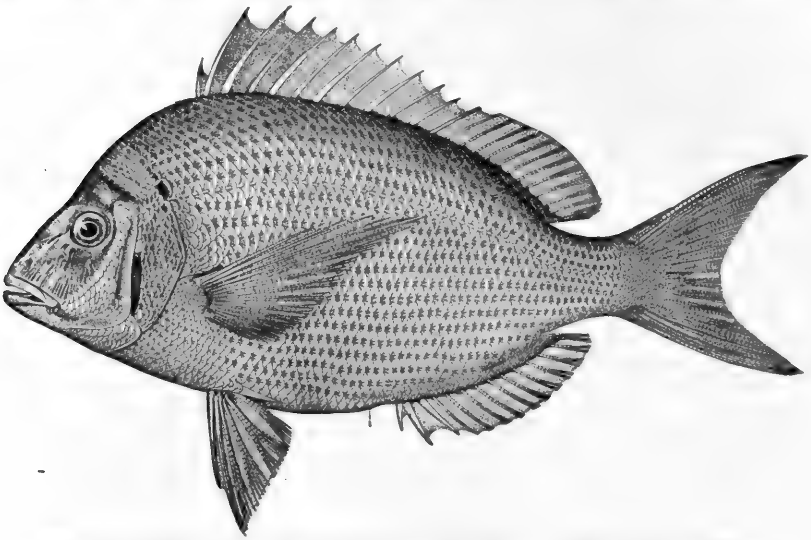


FIG. 281.—Scup, *Stenotomus chrysops* (Linnæus). Wood's Hole, Mass.

the well-known and abundant "schnapper" of Australia, *Pagrus unicolor*. Another but smaller tai or porgy, crimson, sprinkled with blue spots, *Pagrus cardinalis*, occurs in Japan in great abundance, as also two species similar in character but without red, known as *Kurodai* or black tai. These are *Sparus latus* and *Sparus berda*. The gilt-head of the Mediterranean, *Sparus aurata*, is very similar to these Japanese species. *Sparus sarba* in Australia is the tarwhine, and *Sparus australis* the black bream. The numerous species of *Pagellus* abound in the Mediterranean. These are smaller in size than the species of *Pagrus*, red in color and with feebler teeth. *Monotaxis grandoculis*, known as the "mu," is a widely diffused and valuable food-fish of the Pacific islands, greenish in color, with pale cross-bands. Very closely related is also the American scup or fair maid (*Stenotomus chrysops*), one of our commonest pan fishes. In

this genus and in *Calamus* the second interhæmal spine is very greatly enlarged, its concave end formed like a quill-pen and

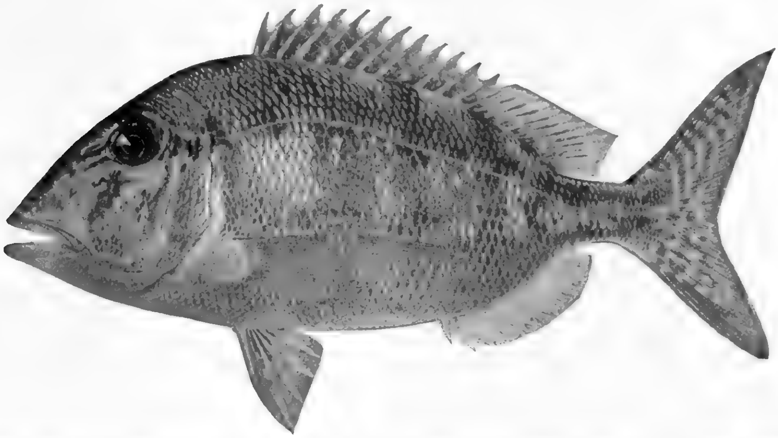


FIG. 282.—*Calamus bajonado* (Bloch & Schneider), Jolt-head Porgy. Pez de Pluma. Family *Sparidæ*.

including the posterior end of the large air-bladder. This arrangement presumably assists in hearing. Of the penfishes,

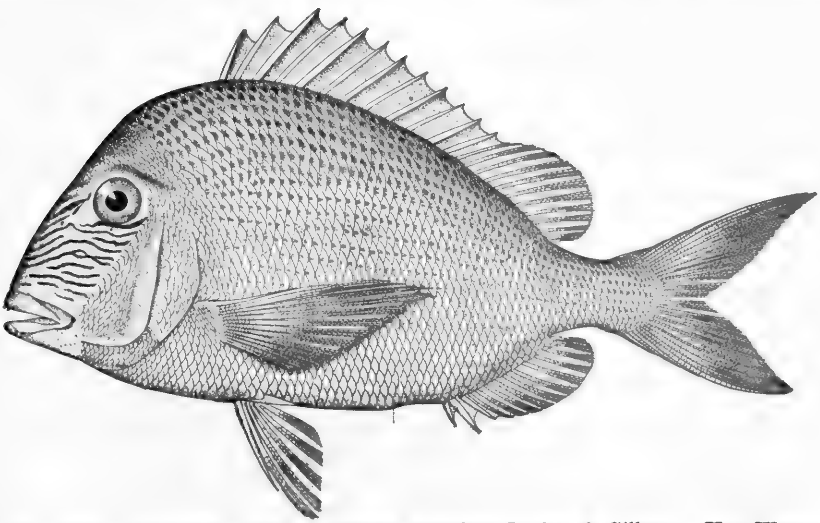


FIG. 283.—Little-head Porgy, *Calamus proridens* Jordan & Gilbert. Key West.

or pez de pluma, numerous species abound in tropical America, where they are valued as food. Of these the bajonado or jolt-head porgy (*Calamus bajonado*) is largest, most common

and dullest in color. *Calamus calamus* is the saucer-eye porgy, and *Calamus proridens*, the little-head porgy. *Calamus leucosteus* is called white-bone porgy, and the small *Calamus arctifrons* the grass-porgy.

The Chopa spina, or pinfish, *Lagodon rhomboides*, is a little porgy with notched incisors, exceedingly common on our South Atlantic coast.

In some of the porgies the front teeth instead of being canine-like are compressed and truncate, almost exactly like human incisors. These species are known as sheepshead, or sargos.

Diplodus sargus and *Diplodus annularis* are common sargos of the Mediterranean, silvery, with a black blotch on the back of

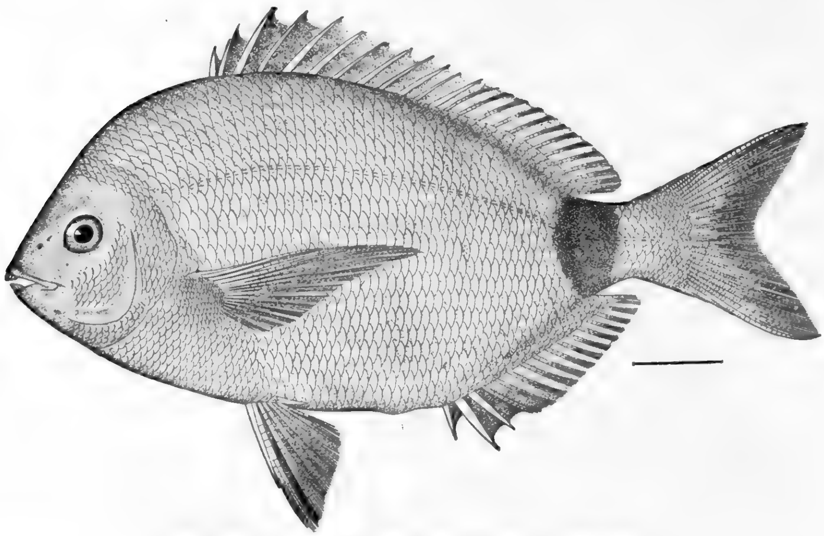


Fig. 284.—*Diplodus holbrooki* Bean. Pensacola.

the tail. *Diplodus argenteus* of the West Indies and *Diplodus holbrooki* of the Carolina coast are very close to these.

The sheepshead, *Archosargus probatocephalus*, is much the most valuable fish of this group. The broad body is crossed by about seven black cross-bands. It is common from Cape Cod to Texas in sandy bays, reaching rarely a weight of fifteen pounds. Its flesh is most excellent, rich and tender. The sheepshead is a quiet bottom-fish, but takes the hook readily and with some spirit. Close to the sheepshead is a smaller species known as Salema (*Archosargus unimaculatus*), with blue

and golden stripes and a black spot at the shoulder. It abounds in the West Indies.

On the coast of Japan and throughout Polynesia are numerous species of *Lethrinus* and related genera, formed and

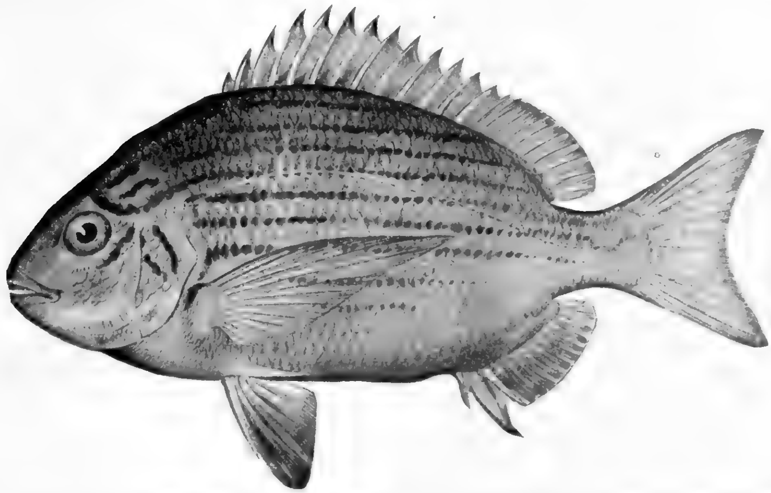


FIG. 285.—*Archosargus unimaculatus* (Bloch), Salema, Striped Sheepshead. Family *Sparidæ*.

colored like snappers, but with molar teeth and the cheek without scales. A common species in Japan is *Lethrinus richardsoni*.

Fossil species of *Diplodus*, *Sparus*, *Pagrus*, and *Pagellus* occur in the Italian Eocene, as also certain extinct genera, *Sparnodus* and *Trigonodon*, of similar type. *Sparnodus macrophthalmus* is abundant in the Eocene of Monte Bolca.

The Picarels: Mænidæ.—The *Mænidæ*, or *Picarels*, are elongate, gracefully formed fishes, remarkable for the extreme protractility of the upper jaw. *Spicara smaris* and several other small species are found in the Mediterranean. *Emmelichthys* contains species of larger size occurring in the West Indies and various parts of the Pacific, chiefly red and very graceful in form and color. *Emmelichthys vittatus*, the boga, is occasionally taken in Cuba, *Erythrichthys schlegeli* is found in Japan and Hawaii.

The Mojarras: Gerridæ.—The *Gerridæ*, or *Mojarras*, have the mouth equally protractile, but the form of the body is different, being broad, compressed, and covered with large

silvery scales. In some species the dorsal spines and the third anal spine are very strong, and in some the second interhæmal is quill-shaped, including the end of the air-bladder, as in *Calamus*. Most of the species, including all the peculiar ones, are American. The smallest, *Eucinostomus*, have the quill-shaped interhæmal

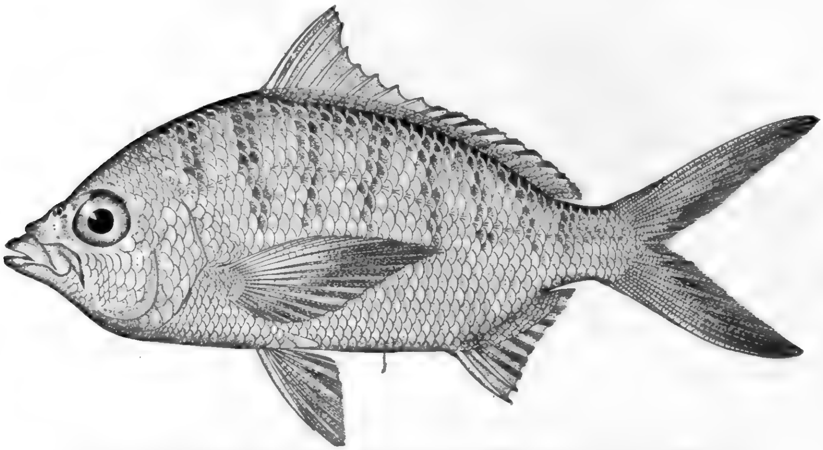


FIG. 286.—Mojarra, *Xystæma cinereum* (Walbaum). Key West.

and the dorsal and anal spines are very weak. The commonest species is the silver jenny, or mojarra de Ley, *Eucinostomus gula*, which ranges from Cape Cod to Rio Janeiro, in the surf along sandy shores. Equally common is *Eucinostomus californiensis* of the Pacific Coast of Mexico, while *Eucinostomus harengulus* of the West Indies is also very abundant. *Ulæma lefroyi* has but two anal spines and the interhæmal very small. It is common through the West Indies. *Xystæma*, with the interhæmal spear-shaped and normally formed, is found in Asia and Polynesia more abundantly than in America, although one species, *Xystæma cinereum*, the broad shad, or Mojarra blanca, is common on both shores of tropical America. *Xystæma gigas* is found in Polynesia, *X. oyena* in Japan, and *X. filamentosum* in Formosa and India. *Xystæma massalongoi* is also fossil in the Miocene of Austria. The species of *Gerres* have very strong dorsal and anal spines and the back much elevated. *Gerres plumieri*, the striped mojarra, *Gerres brasiliensis*, the patao, *Gerres olisthostomus*, the Irish pampano, and *Gerres rhombeus* are some of the numerous species found

on the Florida coast and in the West Indies. The family of *Leiognathidæ*, already noticed (page 287), should stand next to the *Gerridæ*.

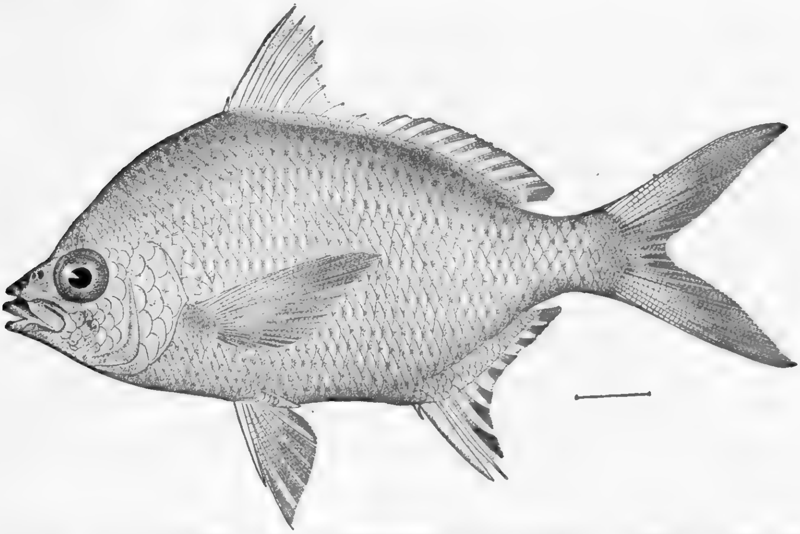


Fig. 287.—Irish Pampano, *Gerres olisthostomus* Goode & Bean. Indian River, Fla.

The Rudder-fishes: Kyphosidæ.—The *Kyphosidæ*, called rudder-fishes, have no molars, the front of the jaws being occupied by incisors, which are often serrated, loosely attached,

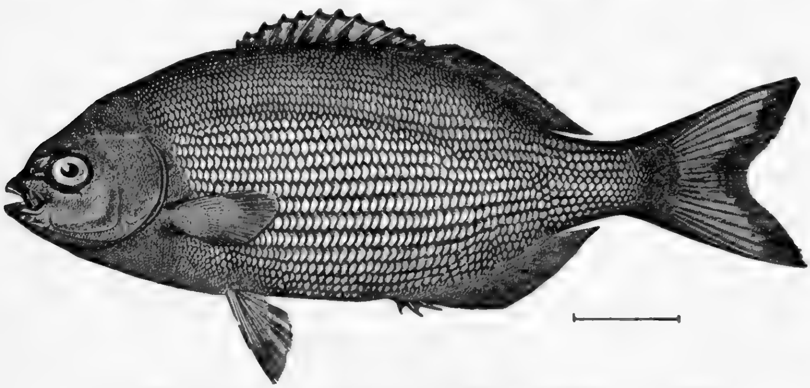


Fig. 288.—Chopa or Rudder-fish, *Kyphosus sectatrix* (Linnæus). Wood's Hole, Mass.

and movable. The numerous species are found in the warm seas and are chiefly herbivorous.

Boops boops and *Boops salpa*, known as boga and salpa,

are elongate fishes common in the Mediterranean. Other Mediterranean forms are *Spondyliosoma cantharus*, *Oblata melanura*, etc. *Girella nigricans* is the greenfish of California, everywhere abundant about rocks to the south of San Francisco, and of considerable value as food. Almost exactly like it is the Mejinadai (*Girella punctata*) of Japan. The best-known members of this group belong to the genus *Kyphosus*. *Kyphosus sectatrix* is the rudder-fish, or Chopa blanca, common in the West Indies and following ships to the northward even as far as Cape Cod, once even taken at Palermo. It is supposed that it is enticed by the waste thrown overboard. *Kyphosus elegans* is found on the west coast of Mexico, *Kyphosus tahmel* in the East Indies and Polynesia, and numerous other species occur in tropical America and along the coasts of southern Asia. *Sectator ocyurus* is a more elongate form of rudder-fish, striped with bright blue and yellow, found in the Pacific. *Medialuna californiensis* is the half-moon fish, or medialuna, of southern California, an excellent food-fish frequently taken on rocky shores. Numerous related species occur in the Indian seas.

Fossil fragments in Europe have been referred to *Boops*, *Spondyliosoma*, and other genera.

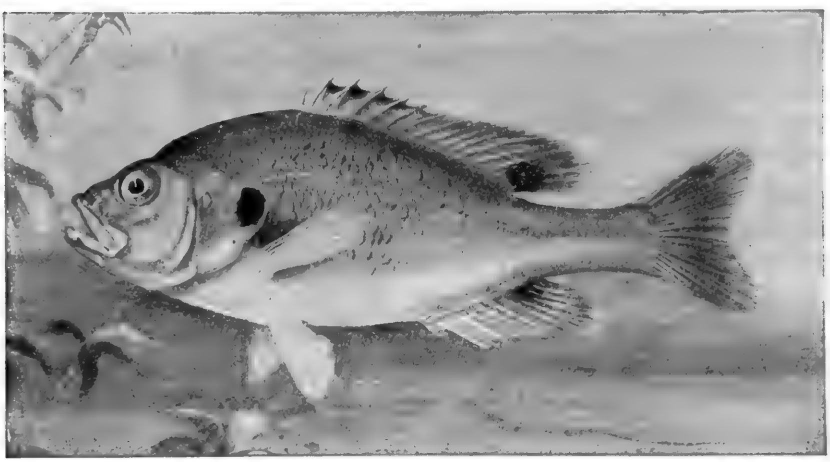


FIG. 288*a*.—Blue-green Sunfish, *Apomotes cyanellus* (Rafinesque). Kansas River. (After Kellogg.)

CHAPTER XX

THE SURMULLETS, THE CROAKERS AND THEIR RELATIVES

THE **Surmullets, or Goatfishes: Mullidæ.**—The *Mullidæ* (Surmullets) are shore-fishes of the warm seas, of moderate size, with small mouth, large scales, and possessing the notable character of two long, unbranched barbels of firm substance at the chin. The dorsal fins are short, well separated, the first of six to eight firm spines. There are two anal spines and the ventral fins, thoracic, are formed of one spine and five rays. The flesh is white and tender, often of very superior flavor. The species are carnivorous,

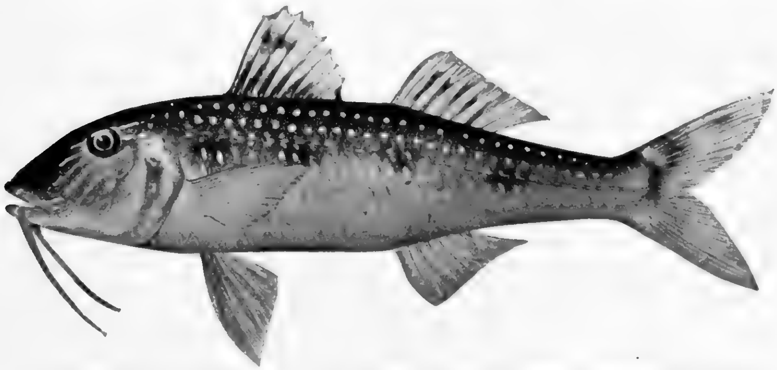


FIG. 289.—Red Goatfish, or Salmonete, *Pseudupeneus maculatus* Bloch. Family *Mullidæ* (Surmullets.)

feeding chiefly on small animals. They are not voracious, and predaceous fishes feed freely on them. The coloration is generally bright, largely red or golden, in nearly all cases with an under layer, below the scales, of red, which appears when the fish is scaled or placed in alcohol. The barbels are often bright yellow, and when the fish swims along the bottom these are carried in advance, feeling the way. Testing the bottom

with their feelers, these fishes creep over the floor of shallow waters, seeking their food.

The numerous species are all very much alike in form, and the current genera are separated by details of the arrangement of the teeth. But few are found outside the tropics.

The surmullet or red mullet of Europe, *Mullus barbatus*, is the most famous species, placed by the Romans above all other fishes unless it be the scarus, *Sparisoma cretense*. From the satirical poets we learn that "enormous prices were paid for a fine fish, and it was the fashion to bring the fish into the dining-room and exhibit it alive before the assembled guests, so that they might gloat over the brilliant and changing colors during the death-agonies." It is red in life, and when the scales are removed, the color is much brighter.

It is an excellent fish, tender and rich, but nowhere so extravagantly valued to-day as was formerly the case in Rome.

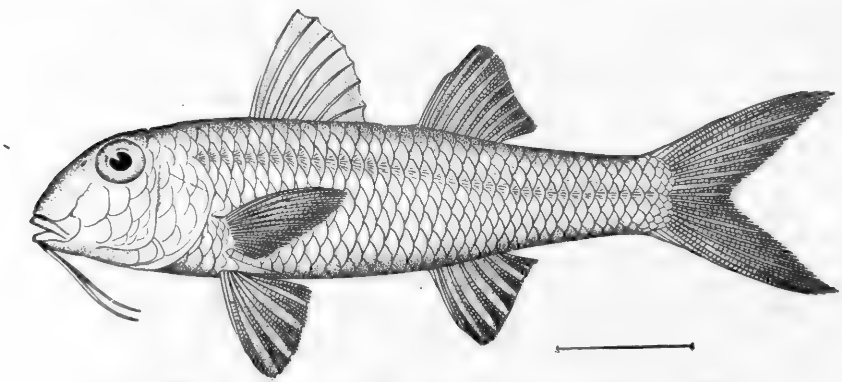


Fig. 290.—Golden Surmullet, *Mullus auratus* Jordan & Gilbert. Wood's Hole, Mass.

Mullus surmuletus is a second European species, scarcely different from *Mullus barbatus*.

Equally excellent as food and larger in size are two Polynesian species known as kumu and munu (*Pseudupeneus porphyreus* and *Pseudupeneus bifasciatus*). *Mullus auratus* is a small surmullet occasionally taken off our Atlantic coast, but in deeper water than that frequented by the European species. *Pseudupeneus maculatus* is the red goatfish or salmonete, common from Florida to Brazil, as is also the yellow goatfish, *Pseudu-*

peneus martinicus, equally valued. Many other species are found in tropical America, Polynesia, and the Indies and Japan. Perhaps the most notable are *Upeneus vittatus*, striped with yellow and with the caudal fin cross-barred and the belly sulphur-yellow, and *Upeneus arge*, similar, the belly white. The common red and black-banded "moana" or goatfish of Hawaii is *Pseudupeneus multifasciatus*.

No fossil *Mullidæ* are recorded, so far as known to us.

The Croakers: Sciænidæ.—The family of *Sciænidæ* (croakers, roncadors) is another of the great groups of food-fishes. The species are found on every sandy shore in warm regions and all of them are large enough to have value as food, while many have flesh of superior quality. None are brightly colored, most of the species being nearly plain silvery.

Special characters are the cavernous structure of the bones of the head, which are full of mucous tracts, the specialization

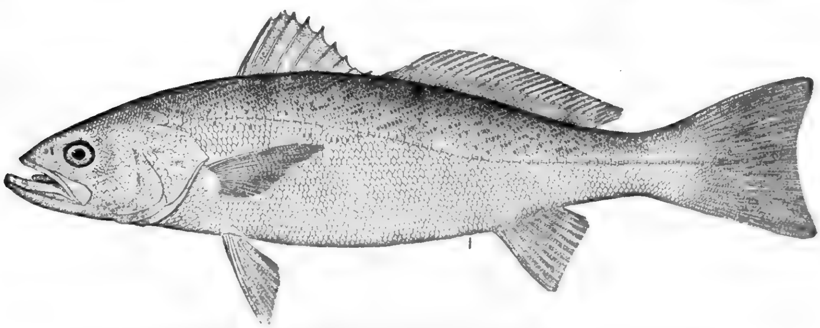


FIG. 291.—Spotted Weakfish, *Cynoscion nebulosus*. Virginia.

(and occasional absence) of the air-bladder, and the presence of never more than two anal spines, one of these being sometimes very large. Most of the species are marine, all are carnivorous; none inhabit rocky places and none descend to depths in the sea. At the least specialized extreme of the family, the mouth is large with strong canines and the species are slender, swift, and predaceous.

The weakfish or squeteague (*Cynoscion regalis*) is a type of a multitude of species, large, swift, voracious, but with tender flesh, which is easily torn. The common weakfish, abundant on our Atlantic coast, suffers much at the hands of its

enemy and associate, the bluefish. It is one of the best of all our food-fishes. Farther south the spotted weakfish (*Cynoscion nebulosus*), very incorrectly known as sea-trout, takes its place, and about New Orleans is especially and justly prized.

The California "bluefish," *Cynoscion parvipinnis*, is very similar to these Atlantic species, and there are many other species of *Cynoscion* on both coasts of tropical America, forming a large part of the best fish-supply of the various markets of the mainland. On the rocky islands, as Cuba, and about coral reefs, *Sciænidæ* are practically unknown. In the Gulf of California, the totuava, *Cynoscion macdonaldi*, reaches a weight of 172 pounds, and the stateliest of all, the great "white sea-bass" of California, *Cynoscion nobilis*, reaches 100 pounds. In these large species the flesh is much more firm than in the weakfish and thus bears shipment better. *Cynoscion* has canines in the upper jaw only and its species are all American. In the East Indies the genus *Otolithes* has strong canines in both jaws. Its numerous species are very similar in form, habits, and value to those of *Cynoscion*. The queenfish, *Seriphus politus*, of the California coast, is much like the others of this series, but smaller and with no canines at all. It is a very choice fish, as are also the species of *Macrodon* (*Ancylodon*) known as pescadillo del red, voracious fishes of both shores of South America.

Plagioscion squamosissimus and numerous species of *Plagioscion* and other genera live in the rivers of South America. A single species, the river-drum, gaspergou, river sheepshead, or thunder-pumper (*Aplodinotus grunniens*), is found in streams in North America. This is a large fish reaching a length of nearly three feet. It is very widely distributed, from the Great Lakes to Rio Usumacinta in Guatemala, whence it has been lately received by Dr. Evermann. This species abounds in lakes and sluggish rivers. The flesh is coarse, and in the Great Lakes it is rarely eaten, having a rank odor. In Louisiana and Texas it is, however, regarded as a good food-fish. In this species the lower pharyngeals are very large and firmly united, while, as in all other *Sciænidæ*, except the genus *Pogonias*, these bones are separated. In all members of the family the ear-bones or otoliths are largely developed, often finely sculptured.

The otoliths of the river-drum are known to Wisconsin boys as "lucky-stones," each having a rude impress of the letter L. The names roncador, drum, thunder-pumper, croaker, and the like refer to the grunting noise made by most *Sciænidæ* in the water, a noise at least connected with the large and divided air-bladder.

Numerous silvery species belong to *Larimus*, *Corvula*, *Odontoscion*, and especially to *Bairdiella*, a genus in which the second anal spine is unusually strong. The mademoiselle, *Bairdiella*

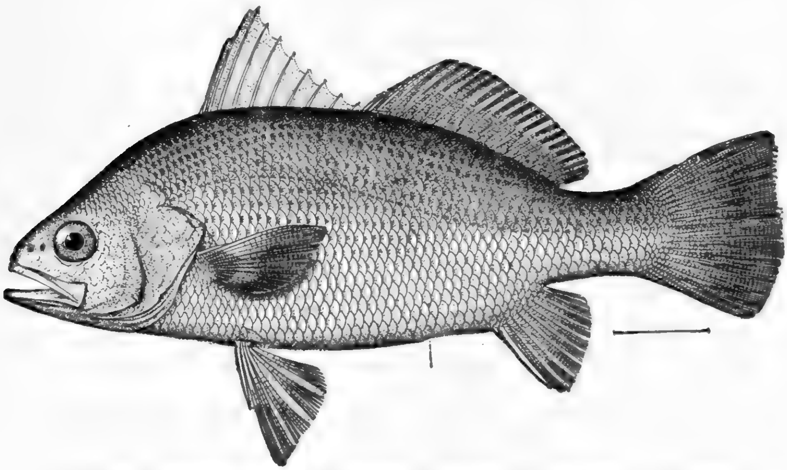


Fig. 292.—Mademoiselle, *Bairdiella chrysura* (Linnæus). Virginia.

chrysura is a pretty fish of our Atlantic coast, excellent as a pan fish. In *Bairdiella ensifera* of Panama the second anal spine is enormously large, much as in a robalo (*Oxylabrax*).

In *Stellifer* and *Nebris*, the head is soft and spongy. *Stellifer lanceolatus* is occasionally taken off South Carolina, and numerous other species of this and related genera are found farther South.

Sciænops ocellata is the red-drum or channel bass of ours South Atlantic coast, a most important food-fish reaching a weight of seventy-five pounds. It is well marked by a black ocellus on the base of the tail. On the coast of Texas, this species, locally called redfish, exceeds in economic value all other species found in that State.

Pseudosciæna aquila, the maigre of southern Europe, is

another large fish, similar in value to the red drum. *Pseudosciæna antarctica* is the kingfish of Australia. To *Sciæna* belong many species, largely Asiatic, with the mouth inferior, without barbels, the teeth small, and the convex snout marked with mucous pores. *Sciæna umbra*, the ombre, is the common European species, *Sciæna saturna*, the black roncador of California, is much like it. *Sciæna deliciosa* is one of the most valued

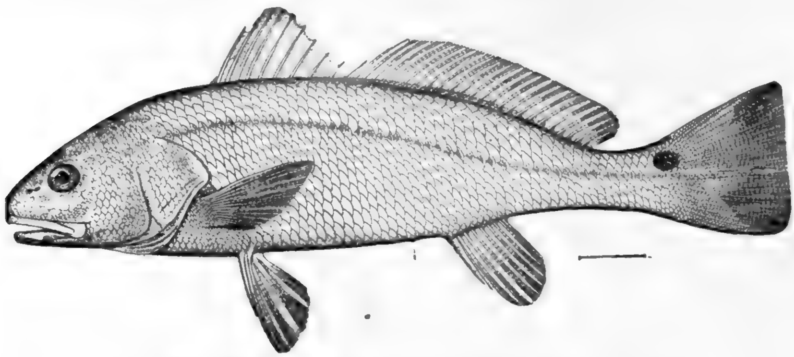


FIG. 293.—Red Drum, *Sciænops ocellata* Linnæus. Texas.

food-fishes of Peru, and *Sciæna argentata* is valued in Japan. Species of *Sciæna* are especially numerous on the coasts of India.

Roncador stearnsi, the California roncador, is a large fish with a black ocellus at the base of the pectoral. It has some importance in the Los Angeles market. The goody, spot, or lafayette (*Leiostomus xanthurus*) is a small, finely flavored species abundant from Cape Cod to Texas. Similar to it but inferior is the little roncador (*Genyonemus lineatus*) of California. The common croaker, *Micropogon undulatus*, is very abundant on our Eastern coast, and other species known as verrugatos or white-mouthed drummers replace it farther South.

In *Umbrina* the chin has a short thick barbel. The species abound in the tropics, *Umbrina cirrosa* in the Mediterranean; *Umbrina coroides* in California, and the handsome *Umbrina roncador*, the yellow-tailed roncador, in southern California. The kingfish, *Menticirrhus*, differs in lacking the air-bladder, and lying on the bottom in shallow water the lower fins are enlarged much as in the darters or gobies. All the species are American. All are dull-colored and all excellent as food. *Menticirrhus saxatilis* is the common kingfish or sea-mink, abundant

from Cape Ann southward, *Menticirrhus americanus* is the equally common sand-whiting of Carolina, and *Menticirrhus*

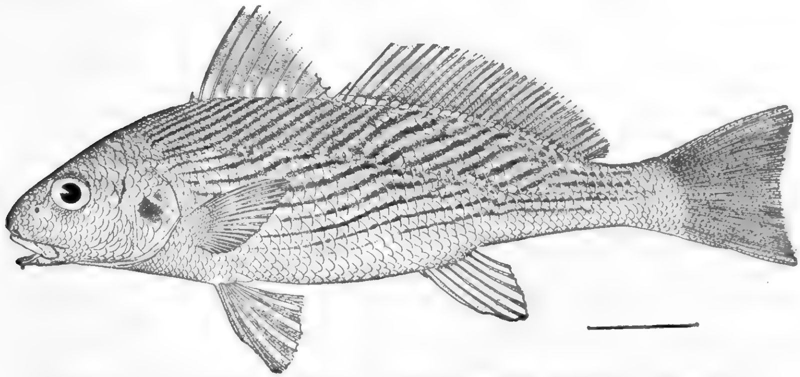


Fig. 294.—Yellow-fin Roncador, *Umbrina sinaloœ* Scofield. Mazatlan.

littoralis the surf-whiting. The California whiting or sand-sucker is *Menticirrhus undulatus.*

Pogonias chromis, the sea-drum, has barbels on the chin and the lower pharyngeals are enlarged and united as in the river-

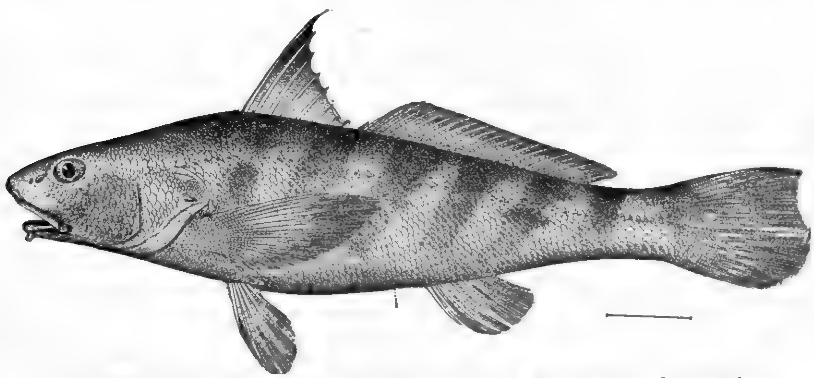


Fig. 295.—Kingfish, *Menticirrhus americanus* (Linnæus). Pensacola.

drum, *Aplodinotus.* It is a coarse fish common on our Atlantic coasts, a large specimen taken at St. Augustine weighing 146 pounds. Other species of this family, belonging to the genus *Eques*, are marked with ribbon-like stripes of black. *Eques lanceolatus*, known in Cuba as serrana, is the most ornate of these species, looking like a butterfly-fish or chætodon.

Several fossil fragments have been doubtfully referred to *Sciœna*, *Umbrina*, *Pogonias*, and other genera. Otoliths or

ear-bones not clearly identifiable are found from the Miocene on. These structures are more highly specialized in this group than in any other.

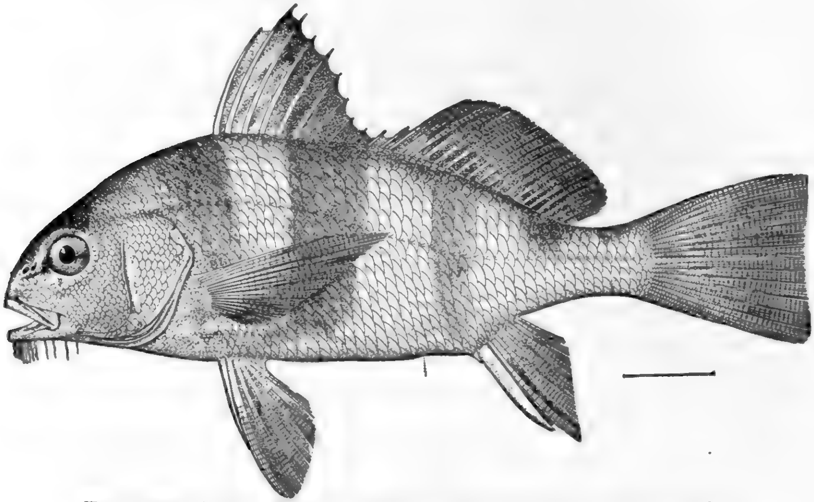


FIG. 296.—Drum, *Pogonias chromis* (Linnæus). Matanzas, Fla.

The Sillaginidæ, etc.—Allied to the *Sciænidæ* is the small family of Kisugos, *Sillaginidæ*, of the coasts of Asia. These are slender, cylindrical fishes, silvery in color, with a general resemblance to small *Sciænas*.

Sillago japonicus, the kisugo of Japan, is a very abundant species, valued as food. *Sillago sihama* ranges from Japan to Abyssinia.

A number of small families, mostly Asiatic, may be appended to the percoid series, with which they agree in general characters, especially in the normal structure of the shoulder-girdle and in the insertion of the pectoral and ventral fins.

The *Lactariidæ* constitute a small family of the East Indies, allied to the *Scriænidæ*, but with three anal spines. The mouth is armed with strong teeth. *Lactarius lactarius* is a food-fish of India.

The *Nandidæ* are small spiny-rayed fishes of the East Indian streams, without pseudobranchiæ.

The *Polycentridæ* are small fresh-water perch-like fishes of the streams of South America, without lateral line and with many anal spines.

The Jawfishes: Opisthognathidæ, etc.—The *Pseudochromipidæ* are marine-fishes of the tropics with the lateral line interrupted, and with a single dorsal. They bear some resemblance to *Plesiops* and other aberrant *Serranidæ.*

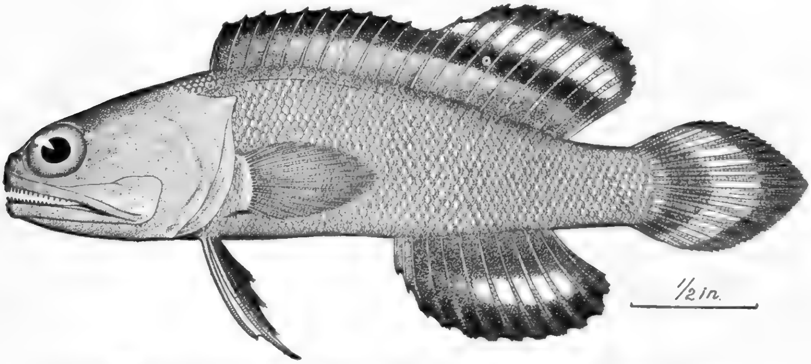


FIG. 297.—*Gnathypops evermanni* Jordan & Snyder. Misaki, Japan.

Very close to these are the *Opistognathidæ* or jawfishes with a single lateral line and the mouth very large. In certain species of *Opisthognathus*, the maxillary, long and curved, extends far behind the head. The few species are found in warm

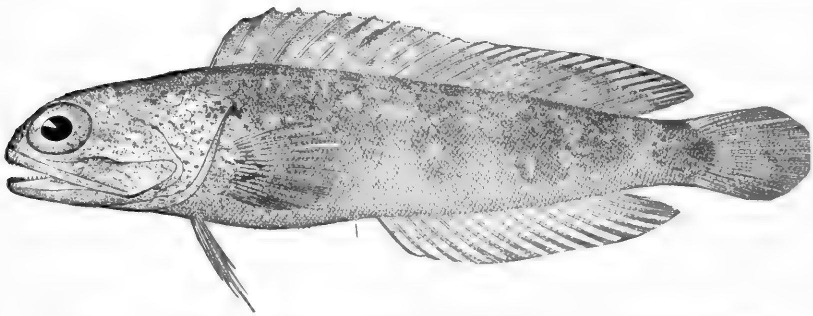


FIG. 298.—Jawfish, *Opisthognathus macrognathus* Poey. Tortugas, Fla.

seas, but always very sparingly. Some of them are handsomely colored.

The Stone-wall Perch: Oplegnathidæ.—A singular group evidently allied to the *Hæmulidæ* is the family of *Oplegnathidæ.* In these fishes the teeth are grown together to form a bony beak like the jaw of a turtle. Except for this character, the species are very similar to ordinary grunts. While the mouth resembles

that of the parrot-fish, it is structurally different and must have been independently developed. *Oplegnathus punctatus*, the "stonewall perch" (ishigakidai), is common in Japan, as is also

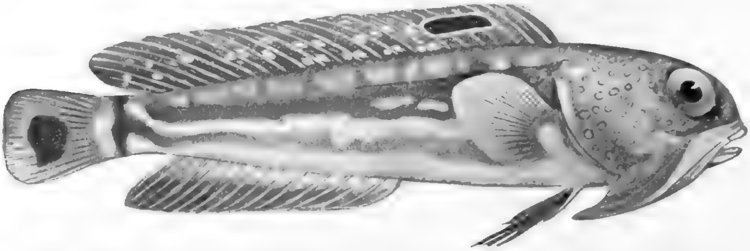


FIG. 299.—*Opisthognathus nigromarginatus*. India. (After Day.)

the banded *Oplegnathus fasciatus*. Other species are found in Australia and Chile.

The Swallowers: Chiasmodontidæ.—The family of swallowers *Chiasmodontidæ*, is made up of a few deep-sea fishes of soft flesh and feeble spines, the opercular apparatus much reduced.

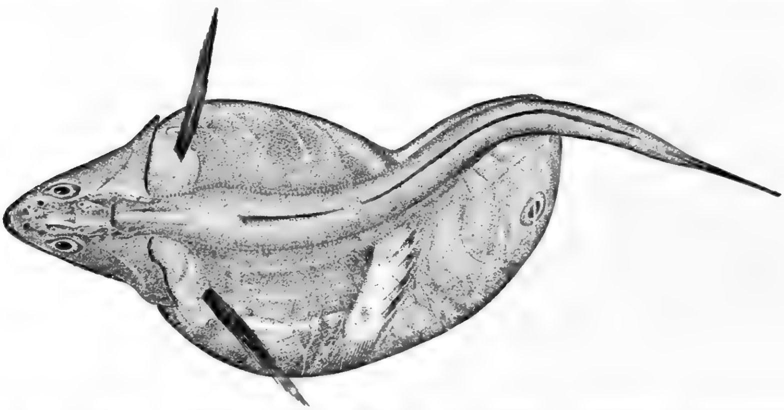


FIG. 300.—Black Swallower, *Chiasmodon niger* Johnson, containing a fish larger than itself. Le Have Bank.

The ventrals are post-thoracic, the rays I, 5, facts which point to some affinity with the *Opisthognathidæ*, although Boulenger places these fishes among the *Percesoces*. *Chiasmodon niger*, the black swallower of the mid-Atlantic, has exceedingly long teeth and the whole body so distensible that it can swallow fishes of many times its own size. According to Gill:

"It espies a fish many times larger than itself, but which, nevertheless, may be managed; it darts upon it, seizes it by

the tail and gradually climbs over it with its jaws, first using one and then the other; as the captive is taken in the stomach and integuments stretch out, and at last the entire fish is passed through the mouth and into the stomach, and the distended belly appears as a great bag, projecting out far backwards and forwards, over which is the swallower with the ventrals dislocated and far away from their normal place. The walls of the stomach and belly have been so stretched that they are transparent, and the species of the fish can be discerned within. But such rapacity is more than the captor itself can stand. At length decomposition sets in, the swallower is forced belly upwards, and the imprisoned gas, as in a balloon, takes it upwards from the depths to the surface of the ocean, and there, perchance, it may be found and picked up, to be taken home for a wonder, as it is really. Thus have at least three specimens found their way into museums—one being in the United States National Museum—and in each the fish in the stomach has been about twice as long, and stouter in proportion, than the swallower—six to twelve times bulkier! Its true habitat seems to be at a depth of about 1,500 fathoms."

Allied to this family is the little group of *Champsodontidæ* of Japan and the East Indies. *Champsodon vorax* looks like a young *Uranoscopus*. The body is covered with numerous lateral lines and cross-lines.

The Malacanthidæ. — The *Malacanthidæ* are elongate fishes, rather handsomely colored, with a strong canine on the premaxillary behind. *Malacanthus plumieri*, the matajuelo blanco, a slender fish of a creamy-brown color, is common in the West Indies. Other species are found in Polynesia, the most notable being *Malacanthus* (or *Oceanops*) *lativittatus*, a large fish of a brilliant sky-blue, with a jet-black lateral band. In Samoa this species is called gatasami, the "eye of the sea."

The Blanquillos: Latilidæ.—The *Latilidæ*, or blanquillos, have also an enlarged posterior canine, but the body is deeper and the flesh more firm. The species reach a considerable size and are valued as food. *Lopholotilus chamæleonticeps* is the famous tilefish dredged in the depths under the Gulf Stream. It is a fish of remarkable beauty, red and golden. This species, Professor Gill writes, "was unknown until 1879, when specimens

were brought by fishermen to Boston from a previously unexplored bank about eighty miles southeast of No Man's Land, Mass. In the fall of 1880 it was found to be extremely abundant everywhere off the coast of southern New England at a depth of from seventy-five to two hundred and fifty fathoms. The form of the species is more compressed, and higher, than in most of the family, and what especially distinguishes it is the development of a compressed, 'fleshy, fin-like appendage over the back part of the head and nape, reminding one of the adipose fin of the salmonids and catfishes.' It is especially notable, too, for the brilliancy of its colors, as well as for its size, being by far larger than any other member of its family. A weight of fifty pounds or more is, or rather, one might say, was frequently attained by it, although such was very far above the average, that being little over ten pounds. In the reach of water referred to, it could once be found abundantly at any time, and caught by hook and line. After a severe gale in March, 1882, millions of tilefish could be seen, or calculated for, on the surface of the water for a distance of about three hundred miles from north to south, and fifty miles from east to west. It has been calculated by Capt. Collins that as many as one thousand four hundred and thirty-eight millions were scattered over the surface. This would have allowed about two hundred and twenty-eight pounds to every man, woman and child of the fifty million inhabitants of the United States! On trying at their former habitat the next fall, as well as all successive years to the present time, not a single specimen could be found where formerly it was so numerous. We have thus a case of a catastrophe which, as far as has been observed, caused complete annihilation of an abundant animal in a very limited period. Whether the grounds it formerly held will be reoccupied subsequently by the progeny of a protected colony remains to be seen, but it is scarcely probable that the entire species has been exterminated." It is now certain that the species is not extinct.

Caulolatilus princeps is the blanquillo or "whitefish" of southern California, a large handsome fish formed like a dolphin, of purplish, olivaceous color and excellent flesh. Other species of *Caulolatilus* are found in the West Indies. *Latilus*

japonicus is the amadai or sweet perch of Japan, an excellent food-fish of a bright crimson color.

The *Pinguipedidæ* of Chile resemble the *Latilidæ*, having also the enlarged premaxillary tooth. The ventrals are, however, thickened and placed farther forward.

The Bandfishes: Cepolidæ.—The small family of *Cepolidæ*, or bandfishes, resemble the *Latilidæ* somewhat and are probably related to them. The head is normally formed, the ventral fins are thoracic, with a spine and five rays, but the body is drawn out into a long eel-like form, the many-rayed dorsal and anal fins meeting around the tail. The few species are crimson in color with small scales. They are used as food, but the flesh is dry and the bones are stiff and numerous. *Cepola tænia* is common in the Mediterranean, and *Acanthocepola krusensterni* abounds in the bays of southern Japan.

The Cirrhitidæ.—The species of the family *Cirrhitidæ* strongly resemble the smaller *Serranidæ* and even *Serranus* itself, but the lower rays of the pectoral fins are enlarged and are undivided, as in the sea-scorpions and some sculpins. In these fishes, however, the bony stay, which characterizes *Scorpænidæ* and *Cottidæ*, is wholly absent. It is, however, considered possible that this interesting family represents the point of separation at which the mail-cheeked fishes become differentiated from the typical perch-like forms. *Goniistius zonatus*, the takanohadai, is a valuable food-fish of Japan, marked by black cross-bands. *Paracirrhites forsteri* and other species of *Cirrhitus* and *Paracirrhites* are very pretty fishes of the coral reefs, abundant in the markets of Honolulu, the spotted *Cirrhitus marmoratus* being the most widely diffused of these. Only one species of this family, *Cirrhitus rivulatus*, a large fish, green, with blue markings, is found in American waters. It frequents the rocky shores of the west coast of Mexico.

Allied to the *Cirrhitidæ* is the small family of *Latrididæ*, with a long dorsal fin deeply divided, and the lower rays of the pectoral similarly modified. *Latris hecateia* is called the "trumpeter" in Australian waters. It is one of the best food-fishes of Australia, reaching a weight of sixty to eighty pounds.

Another small family showing the same peculiar structure of the pectoral fin is that of the *Aplodactylidæ*. The species

of *Aplodactylus* live on the coasts of Chile and Australia. They are herbivorous fishes, with flat, tricuspid teeth, and except for their pectoral fins are very similar to the *Kyphosidæ*.

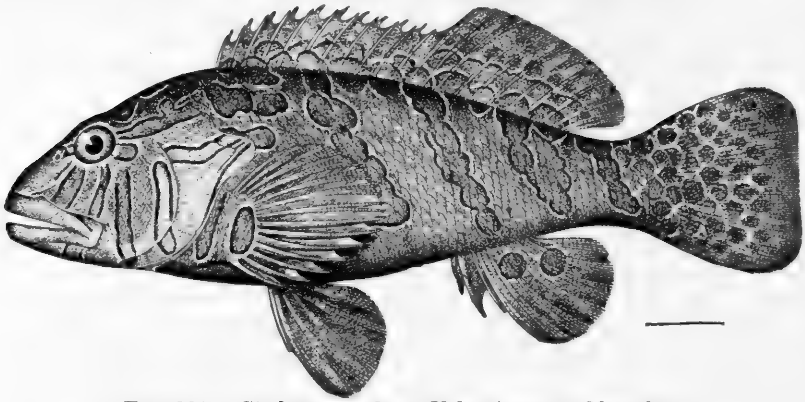


Fig. 301.—*Cirrhitus rivulatus* Valenciennes. Mazatlan.

The Sandfishes: Trichodontidæ.—In the neighborhood of the *Latrididæ*, Dr. Boulenger places the *Trichodontidæ* or sandfishes, small, scaleless, silvery fishes of the northern Pacific. These

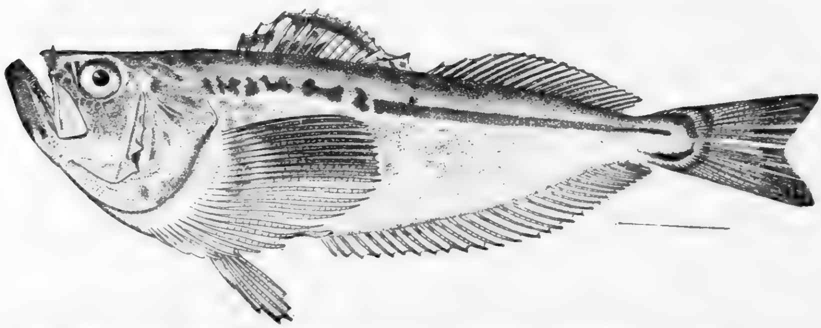


Fig. 302.—Sandfish, *Trichodon trichodon* (Tilesius). Shumagin Islands, Alaska.

are much compressed in body, with very oblique mouths, with fringed lips and, as befits their northern habitat, with a much increased number of vertebræ. They bury themselves in sand under the surf, and the two species, *Trichodon trichodon* and *Arctoscopus japonicus*, range very widely in the regions washed by the Japan current. These species bear a strong resemblance to the star-gazers (*Uranoscopus*), but this likeness seems to be superficial only.

CHAPTER XXI

LABYRINTHICI AND HOLCONOTI.

THE **Labyrinthine Fishes.**—An offshoot of the *Percomorphi* is the group of *Labyrinthici*, composed of perch-like fishes which have a very peculiar structure to the pharyngeal bones and respiratory apparatus. This feature is thus described by Dr. Gill:

"The upper elements of one of the pairs of gill-bearing arches are peculiarly modified. The elements in question (called branchihyal) of each side, instead of being straight and solid, as in most fishes, are excessively developed and provided with several thin plates or folds, erect from the surface of the bones and the roof of the skull, to which the bones are attached. These plates, by their intersection, form chambers, and are lined with a vascular membrane, which is supplied with large blood-vessels. It was formerly supposed that the chambers referred to had the office of receiving and retaining supplies of water which should trickle down and keep the gills moist; such was supposed to be an adaptation for the sustentation of life out of the water. The experiments of Surgeon Day, however, throw doubt upon this alleged function, and tend to show: (1) that these fishes died when deprived of access to atmospheric air, not from any deleterious properties either in the water or in the apparatus used, but from being unable to subsist on air obtained solely from the water, aerial respiration being indispensable; (2) that they can live in moisture out of the water for lengthened periods, and for a short, but variable period in water only; and (3) that the cavity or receptacle does not contain water, but has a moist secreting surface, in which air is retained for the purpose of respiration. It seems probable that the air, after having been supplied for aerial respiration, is ejected by the mouth, and not swallowed to be

discharged per anum. In fine, the two respiratory factors of the branchial apparatus have independent functions: (1) the labyrinthiform, or branchihyal portion, being a special modification for the respiration of atmospheric air, and (2) the gill filaments discharging their normal function. If, however, the fish is kept in water and prevented from coming to the surface to swallow the atmospheric air, the labyrinthiform apparatus becomes filled with water which cannot be discharged, owing to its almost non-contractile powers. There is thus no means of emptying it, and the water probably becomes carbonized and unfit for oxygenizing the blood, so that the whole of the respiration is thus thrown on the branchiæ. This will account for the fact that when the fish is in a state of quiescence, it lives much longer than when excited, whilst the sluggishness sometimes evinced may be due to poisoned or carbonized blood."

Four families of labyrinth-gilled fishes are recognized by Professor Gill; and to these we may append a fifth, which, however, lacks the elaborate structures mentioned above and which shows other evidences of degeneration.

The Climbing-perches: Anabantidæ.—The family of *Anabantidæ*, according to Gill, "includes those species which have the

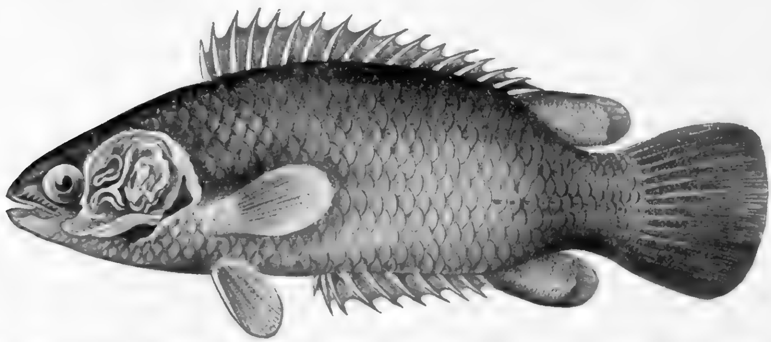


Fig. 303.—The Climbing Perch, *Anabas scandens* Linnæus. Opercle cut away to show the gill-labyrinth.

mouth of moderate size and teeth on the palate (either on the vomer alone, or on both the vomer and palatine bones). To the family belongs the celebrated climbing-fish.

"The climbing-fish (*Anabas scandens*) is especially noteworthy for the movability of the sub-operculum. The oper-

culum is serrated. The color is reddish olive, with a blackish spot at the base of the caudal fin; the head, below the level of the eye, grayish, but relieved by an olive band running from the angle of the mouth to the angle of the pre-operculum, and with a black spot on the membrane behind the hindermost spines of the operculum.

"The climbing-fish was first made known in a memoir, printed in 1797, by Daldorf, a lieutenant in the service of the Danish East India Company at Tranquebar. Daldorf called it *Perca scandens*, and affirmed that he himself had taken one of these fishes, clinging by the spine of its operculum in a slit in the bark of a palm (*Borassus flabelliformis*) which grew near a pond. He also described its mode of progression; and his observations were substantially repeated by the Rev. Mr. John, a missionary resident in the same country. His positive evidence was, however, called into question by those who doubted on account of hypothetical considerations. Even in popular works not generally prone to even a judicious skepticism, the accounts were stigmatized as unworthy of belief. We have, however, in answer to such doubts, too specific information to longer distrust the reliability of the previous reports.

"Mr. Rungasawmy Moodeliar, a native assistant of Capt. Jesse Mitchell of the Madras Government Central Museum, communicated to his superior the statement that 'this fish inhabits tanks or pools of water, and is called *Panai feri*, i.e., the fish that climbs palmyra-trees. When there are palmyra-trees growing by the side of a tank or pool, when heavy rain falls and the water runs profusely down their trunks, this fish, by means of its opercula, which move unlike those of other fishes, crawls up the tree sideways (i.e., inclining to the sides considerably from the vertical) to a height of from five to seven feet, and then drops down. Should this fish be thrown upon the ground, it runs or proceeds rapidly along in the same manner (sideways) as long as the mucus on it remains.'

"These movements are effected by the opercula, which, it will be remembered, are unusually mobile in this species; they can, according to Captain Mitchell (and I have verified the statement), be raised or turned outwards to nearly a right angle with the body, and when in that position, the suboper-

culum distends a little, and it appears that it is chiefly by the spines of this latter piece that the fish takes a purchase on the tree or ground. 'I have,' says Captain Mitchell, 'ascertained by experiment that the mere closing of the operculum, when the spines are in contact with any surface, even common glass, pulls an ordinary-sized fish forwards about half an inch,' but it is probable that additional force is supplied by the caudal and anal fins, both of which, it is said, are put in use when climbing or advancing on the ground; the motion, in fact, is described as a wriggling one.

"The climbing-fish seems to manifest an inclination to ascend streams against the current, and we can now understand how, during rain, the water will flow down the trunk of a tree, and the climbing-fish, taking advantage of this, will ascend against the down-flow by means of the mechanism already described, and by which it is enabled to reach a considerable distance up the trunk." (Gill.)

The Gouramis: Osphromenidæ.—"The *Osphromenidæ* are fishes with a mouth of small size, and destitute of teeth on the palate. To this family belongs the gourami, whose praises have been so often sung, and which has been the subject of many efforts for acclimatization in France and elsewhere by the French.

"The gourami (*Osphromenus goramy*) has an oblong, oval form, and, when mature, the color is nearly uniform, but in the young there are black bands across the body, and also a blackish spot at the base of the pectoral fin. The gourami, if we can credit reports, occasionally reaches a gigantic size, for it is claimed that it sometimes attains a length of 6 feet, and weighs 150 pounds, but if this is true, the size is at least exceptional, and one of 20 pounds is a very large fish; indeed, they are considered very large if they weigh as much as 12 or 14 pounds, in which case they measure about 2 feet in length.

"The countries in which the gourami is most at home lie in the intertropical belt. The fish is assiduous in the care of its young, and prepares a nest for the reception of eggs. The bottom selected is muddy, the depth variable within a narrow area, that is, in one place about a yard, and near by several yards deep.

"They prefer to use, for the nests, tufts of a peculiar grass

(*Panicum jumentorum*) which grows on the surface of the water, and whose floating roots, rising and falling with the movements of the water, form natural galleries, under which the fish can conceal themselves. In one of the corners of the pond, among the plants which grow there, the gouramis attach their nest, which is of a nearly spherical form, and composed of plants and mud, and considerably resembles in form those of some birds.

"The gourami is omnivorous, taking at times flesh, fish, frogs, insects, worms, and many kinds of vegetables; and on account of its omnivorous habit, it has been called by the French colonists of Mauritius *porc des rivières*, or 'water-pig.' It is, however, essentially a vegetarian, and its adaptation for this diet is indicated by the extremely elongated intestinal canal, which is many times folded upon itself. It is said to be especially fond of the leaves of several araceous plants. Its flesh is, according to several authors, of a light-yellow straw-color, firm and easy of digestion. They vary in quality with the nature of the waters inhabited, those taken from a rocky river being much superior to those from muddy ponds; but those dwelling at the mouth of rivers, where the water is to some extent brackish, are the best of all. Again, they vary with age; and the large, overgrown fishes are much less esteemed than the small ones. They are in their prime when three years old. Dr. Vinson says the flavor is somewhat like that of carp; and, if this is so, we may entertain some skepticism as to its superiority; but the unanimous testimony in favor of its excellence naturally leads to the belief that the comparison is unfair to the gourami.

"Numerous attempts have been made by the French to introduce the gourami into their country, as well as into several of their provinces; and for a number of years consignments of the eggs, or the young, or adult fish, were made. Although at least partially successful, the fish has never been domiciliated in the Republic, and, indeed, it could not be reasonably expected that it would be, knowing, as we do, its sensitiveness to cold and the climates under which it thrives.

"The fish of paradise (*Macropodus viridi-auratus*) is a species remarkable for its beauty and the extension of its fins, and

especially of the ventrals, which has obtained for it the generic name *Macropodus*. To some extent this species has also been made the subject of fish-culture, but with reference to its beauty and exhibition in aquaria and ponds, like the goldfish, rather than for its food qualities.

"The only other fish of the family that needs mention is the fighting-fish (*Betta pugnax*). It is cultivated by the natives of Siam, and a special race seems to have been the result of such cultivation. The fishes are kept in glasses of water and fed, among other things, with the larvæ of mosquitoes or other aquatic insects. 'The Siamese are as infatuated with the combats of these fishes as the Malays are with their cock-fights, and stake on the issue considerable sums, and sometimes their own persons and families. The license to exhibit fish-fights is farmed, and brings a considerable annual revenue to the king of Siam. The species abounds in the rivulets at the foot of the hills of Penang. The inhabitants name it 'pla-kat,' or the 'fighting-fish.' "

The *Helostomidæ* are herbivorous, with movable teeth on the lips and with long intestines. *Helostoma temmincki* lives in the rivers of Java, Borneo, and Sumatra.

The *Luciocephalidæ* of East Indian rivers have the suprabranchial organ small, formed of two gill-arches dilated by a membrane. In these species there are no spines in the dorsal and anal, while in the *Anabantidæ* and *Osphromenidæ* numerous spines are developed both in the dorsal and anal. *Luciocephalus pulcher* indicates a transition toward the *Ophicephalidæ*.

The Snake-head Mullets: Ophicephalidæ.—The family of *Ophicephalidæ*, snake-head mullets, or China-fishes, placed among the *Percesoces* by Cope and Boulenger, seems to us nearer the Labyrinthine fishes, of which it is perhaps a degenerate descendant. The body is long, cylindrical, covered with firm scales which on the head are often larger and shield-like. The mouth is large, the head pike-like, and the habit carnivorous and voracious. There are no spines in any of the fins, but the thoracic position of the ventrals indicates affinity with perch-like forms and the absence of ventral spines seems rather a feature of degradation, the more so as in one genus (*Channa*) the ventrals are wanting altogether. The numerous species are found in

the rivers of southern China and India, crossing to Formosa and to Africa. They are extremely tenacious of life, and are carried alive by the Chinese to San Francisco and to Hawaii, where they are now naturalized, being known as "China-fishes."

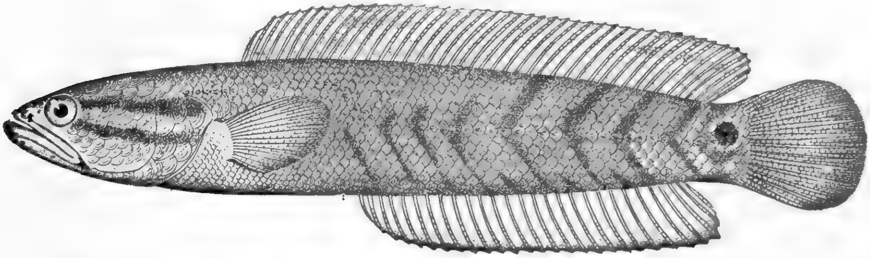


FIG. 304.—*Channa formosana* Jordan & Evermann. Streams of Formosa.

These fishes have no special organ for holding water on the gills, but the gill space may be partly closed by a membrane. According to Dr. Günther, these fishes are "able to survive drought living in semi-fluid mud or lying in a torpid state below the hard-baked crusts of the bottom of a tank from which every drop of water has disappeared. Respiration is

FIG. 305.—Snake-headed China-fish, *Ophicephalus barca*. India. (After Day.)

probably entirely suspended during the state of torpidity, but whilst the mud is still soft enough to allow them to come to the surface, they rise at intervals to take in a quantity of air, by means of which their blood is oxygenized. This habit has been observed in some species to continue also to the period of the year in which the fish lives in normal water, and individuals which are kept in a basin and prevented from coming to the surface and renewing the air for respiratory purposes are suffocated. The particular manner in which the accessory branchial cavity participates in respiratory functions is not known. It is a simple cavity, without an accessory branchial organ, the

opening of which is partly closed by a fold of the mucous membrane."

Ophicephalus striatus is the most widely diffused species in China, India, and the Philippines, living in grassy swamps and biting at any bait from a live frog to an artificial salmon-fly. It has been introduced into Hawaii. *Ophicephalus marulius* is another very common species, as is also *Channa orientalis*, known by the absence of ventral fins.

Suborder Holconoti, the Surf-fishes.—Another offshoot from the perch-like forms is the small suborder of *Holconoti* (ὅλκος, furrow; νῶτος, back). It contains fishes percoid in appearance, with much in common with the *Gerridæ* and *Sparidæ*, but with certain

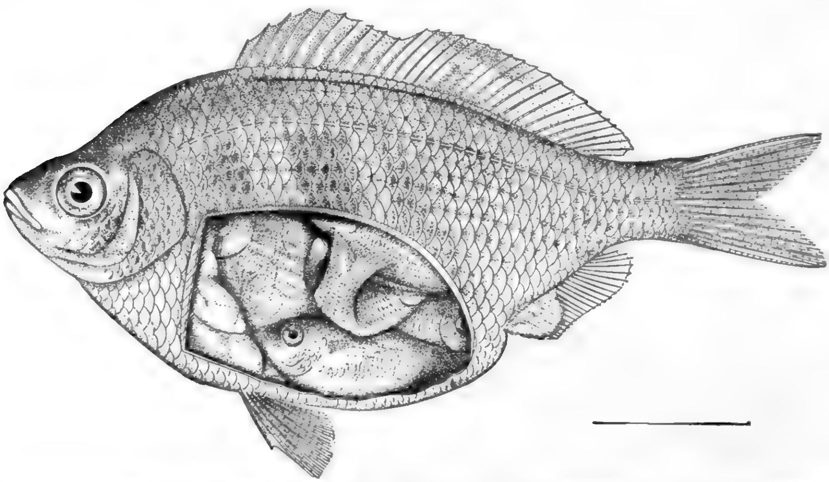


Fig. 306.—White Surf-fish, viviparous, with young, *Cymatogaster aggregatus* Gibbons. San Francisco.

striking characteristics not possessed by any perch or bass. All the species are viviparous, bringing forth their young alive, these being in small number and born at an advanced stage of development. The lower pharyngeals are solidly united, as in the *Labridæ*, a group which these fishes resemble in scarcely any other respects. The soft dorsal and anal are formed of many fine rays, the anal being peculiarly modified in the male sex. The nostrils, ventral fins, and shoulder-girdle have the structure normal among perch-like fishes, and the dorsal furrow, which suggested to Agassiz the name of *Holconoti*, is also found among various perch-like forms.

The Embiotocidæ.—The group contains a single family, the *Embiotocidæ*, or surf-fishes. All but two of the species are confined

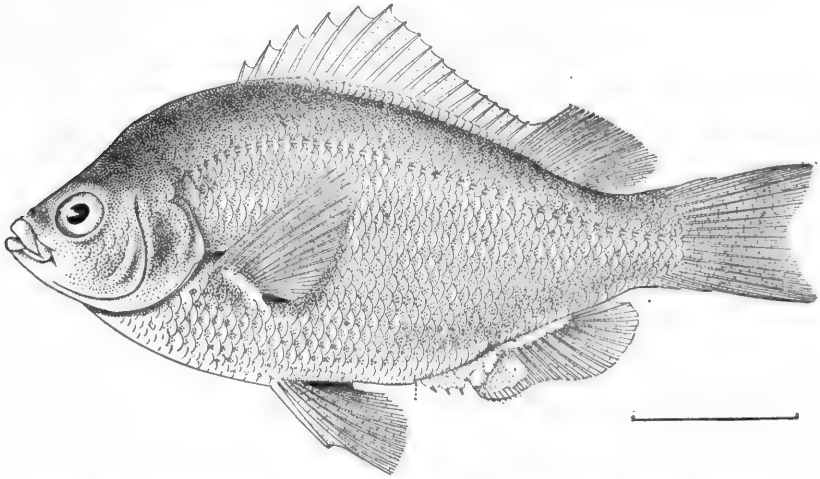


Fig. 307.—Fresh-water Viviparous Perch, *Hysterocarpus traski* Gibbons. Sacramento River.

to California, these two living in Japan. The species are relatively small fishes, from five inches to eighteen inches in length, with rather large, usually silvery scales, small mouths and small teeth. They feed mainly on crustaceans, two or three species being herbivorous. With two exceptions, they inhabit

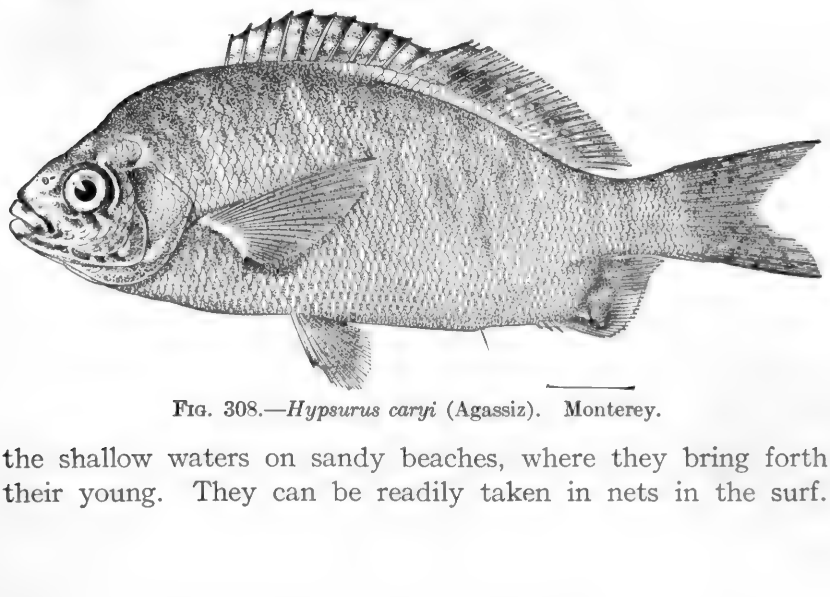


Fig. 308.—*Hypsurus caryi* (Agassiz). Monterey.

the shallow waters on sandy beaches, where they bring forth their young. They can be readily taken in nets in the surf.

As food-fishes they are rather inferior, the flesh being somewhat watery and with little flavor. Many are dried by the

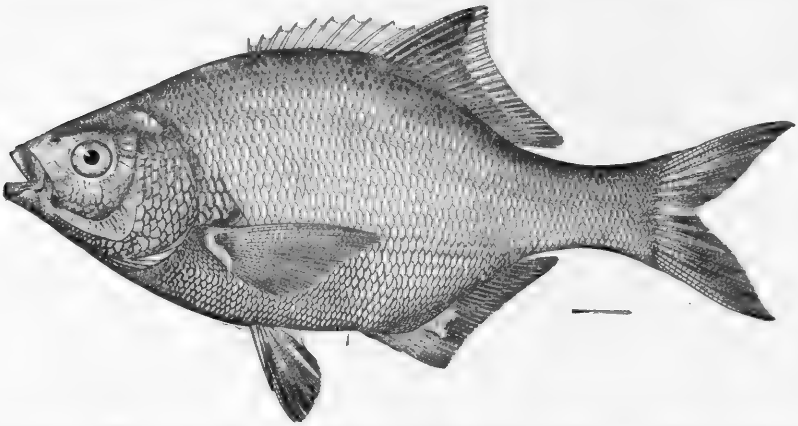


Fig. 309.—White Surf-fish, *Damalichthys argyrosomus* (Girard). British Columbia

Chinese. The two exceptions in distribution are *Hysterocarpus traski*, which lives exclusively in fresh waters, being confined to the lowlands of the Sacramento Basin, and *Zalembius rosaceus*, which descends to considerable depths in the sea. In *Hysterocarpus* the spinous dorsal is very greatly developed,

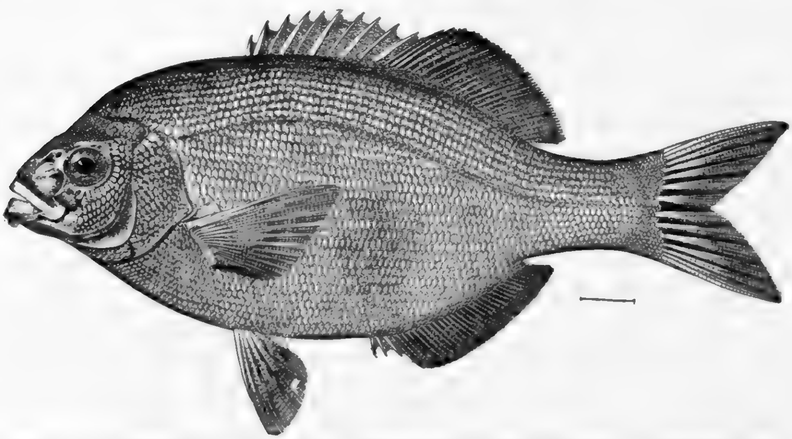


Fig. 310.—Thick-lipped Surf-fish, *Rhacochilus toxotes* Agassiz. Monterey, Cal.

seventeen stout spines being present, the others having but eight to eleven and these very slender.

The details of structure vary greatly among the different

species, for which reason almost every species has been properly made the type of a distinct genus. The two species found in Japan are *Ditrema temmincki* and *Neoditrema ransonneti*. In the latter species the female is always toothless. Close to *Ditrema* is the blue surf-fish of California, *Embiotoca jacksoni*, the first discovered and perhaps the commonest species. *Tæniotoca lateralis* is remarkable for its bright coloration, greenish, with orange stripes. *Hypsurus caryi*, still brighter in color, orange, green and black, has the abdominal region very long. *Phanerodon furcatus* and *P. atripes* are dull silvery in color, as in *Damalichthys argyrosomus*, the white surf-fish, which ranges northward to Vancouver Island, and is remarkable for the extraordinary size of its lower pharyngeals. *Holconotus rhodoterus* is a large, rosy species, and *Amphistichus*

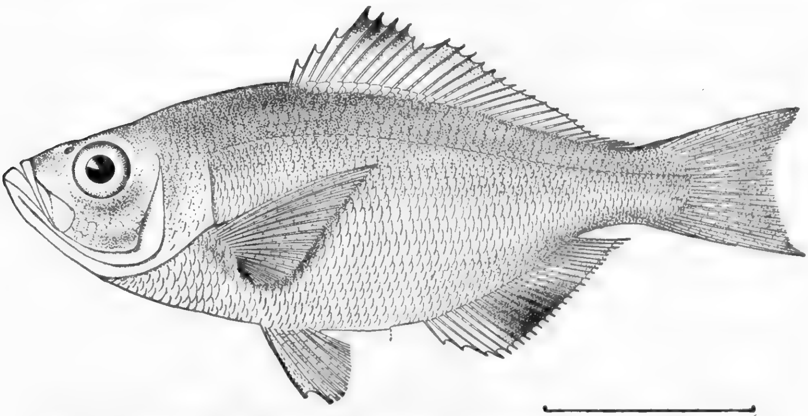


Fig. 311.—Silver Surf-fish (viviparous), *Hypocritichthys analis* (Agassiz). Monterey.

argenteus a large species with dull yellowish cross-bands. *Rhachochilus toxotes* is the largest species in the family and the one most valued as food. It is notable for its thick, drooping, ragged lips. *Hyperprosopon arcuatus*, the wall-eye surf-fish, is brilliantly silvery, with very large eyes. *H. agassizi* closely resembles it, as does also the dwarf species, *Hypocritichthys analis*, to which the Japanese *Neoditrema ransonneti* is very nearly related. The other species are all small. *Abeona minima* and *A. aurora* feed on seaweed. *Brachyistius frenatus* is the smallest of all, orange-red in color, while its relative,

Zalembius rosaceus, is handsomest of all, rose-red with a black lateral spot. *Cymatogaster aggregatus*, the surf-shiner, is a little fish, excessively common along the California coast, and from its abundance it has been selected by Dr. Eigenmann as the basis of his studies of these fishes. In this species the male shows golden and black markings, which are wanting in the silvery female, and the anterior rays of the anal are thickened or otherwise modified.

No fossil embiotocoids are recorded.

The viviparity of the Embiotocidæ was first made known by Dr. A. C. Jackson in 1863 in a letter to Professor Agassiz. From this letter we make the following extracts:

"A few days, perhaps a week, after the four trials, and on the *7th of June*, I rose early in the morning for the purpose of taking a mess of fish for breakfast, pulled to the usual place, baited with crabs, and commenced fishing, the wind blowing too strong for profitable angling; nevertheless on the first and second casts I fastened the two fishes, male and female, that I write about, and such were their liveliness and strength that they endangered my slight trout rod. I, however, succeeded in bagging both, though in half an hour's subsequent work I got not even a nibble from either this or any other species of fish. I determined to change the bait, to put upon my hook a portion of the fish already caught, and cut for that purpose into the larger of the two fish caught. I intended to take a piece from the thin part of the belly, when what was my surprise to see coming from the opening thus made *a small live fish*. This I at first supposed to be prey which this fish had swallowed, but on further opening the fish I was vastly astonished to find next to the back of the fish and slightly attached to it *a long very light violet bag, so clear and so transparent that I could already distinguish through it the shape, color, and formation of a multitude* of small fish (*all facsimiles of each other*), with which it was well filled. I took it on board (we were occupying a small vessel which we had purchased for surveying purposes). When I opened the bag, I took therefrom *eighteen* more of the young fish, precisely like in size, shape, and color the first I had accidentally extracted. The *mother was very large round her center and of a very dark-brown color, ap-*

proaching about the back and on the fins a black color, and a remarkably vigorous fish. The young which I took from her were in shape, save as to rotundity, perfect miniatures of the mother, formed like her, and of the same general proportions, except that the old one was (probably owing to her pregnancy) much broader and wider between the top of the dorsal and the ventral fins in proportion to her length than the young were. *As to color, they were in all respects like the mother, though the shades were many degrees lighter.* Indeed, they were in all respects like their mother and like each other, the same peculiar mouth, the same position and shape of the fins, and the same eyes and gills, and there cannot remain in the mind of any one who sees the fish in the same state that I did a single doubt that these young were the offspring of the fish from whose body I took them, and *that this species of fish gives birth to her young alive and perfectly formed, and adapted to seeking its own livelihood in the water. The number of young in the bag was nineteen* (I fear I misstated the number in my former letter), *and every one as brisk and lively and as much at home in a bucket of salt water as if they had been for months accustomed to the water.* The male fish that was caught was not quite as large as the female, either in length or circumference, and altogether a more slim fish. I think we may reasonably expect to receive the specimens by the first of December. But I can hardly hope to get satisfactory specimens of the fish as I found it, with young well grown, before the return of the same season, viz., June. By that time I trust the facts will be fully decided, and the results, as important as they may be, fully appreciated."

Dr. Jackson's specimens came from Sausalito Bay, near San Francisco. Soon after the publication of this letter a similar discovery was made independently by Dr. William P. Gibbons, of Alameda. Still other specimens were made known in 1854 by Dr. Charles Girard, these having been collected in connection with the United States Pacific Railroad Surveys. The species first examined by Dr. Jackson was named by Agassiz *Embiotoca jacksoni.*

In Professor Agassiz's comments on Dr. Jackson's discovery he makes the following observations (*Amer. Jour. Science and Arts*, 1854):

"The female genital apparatus in the state of pregnancy consists of a large bag the appearance of which in the living animal has been described by Mr. Jackson. Upon the surface of it large vascular ramifications are seen, and it is subdivided internally into a number of distinct pouches, opening by wide slits into the lower part of the sac. This sac seems to be nothing but the widened lower end of the ovary, and the pouches within it to be formed by the folds of the ovary itself. In each of these pouches a young is wrapped up as in a sheet, and all are packed in the most economical manner as far as saving space is concerned, some having their head turned forwards and others backwards. *This is, therefore, a normal ovarian gestation.* The external genital opening is situated behind the anus, upon the summit and in the center of a conical protuberance formed by a powerful sphincter, kept in its place by two strong transverse muscles attached to the abdominal walls. The number of young contained in this sac seems to vary. Mr. Jackson counted nineteen; I have seen only eight or nine in the specimens sent by Mr. Cary, but since these were open when received it is possible that some had been taken out. However, their size is most remarkable in proportion to the mother. In a specimen of *Emb. jacksoni* 10½ inches long and 4½ high the young were nearly 3 inches long and 1 inch high; and in an *Emb. caryi* 8 inches long and 3¼ high the young were 2¾ inches long and ⅞ of an inch high. Judging from their size, I suspected for some time that the young could move in and out of this sac like young opossums, but on carefully examining the position of the young in the pouches, and also the contracted condition of the sphincter at the external orifice of the sexual organs, I remained satisfied that this could not be the case, and that the young which Mr. Jackson found so lively after putting them in a bucket of salt water had then for the first time come into free contact with the element in which they were soon to live; but at the same time it can hardly be doubted that the water penetrates into the marsupial sac, since these young have fully developed gills. The size of the young compared with that of the mother is very remarkable, being full one-third its length in the one, and nearly so in the other species. Indeed these young Embiotocæ, not yet hatched, are three or

four times larger than the young of a Pomotis (of the same size) a full year old. In this respect these fishes differ from all the other viviparous species known to us. There is another feature about them of considerable interest, that while the two

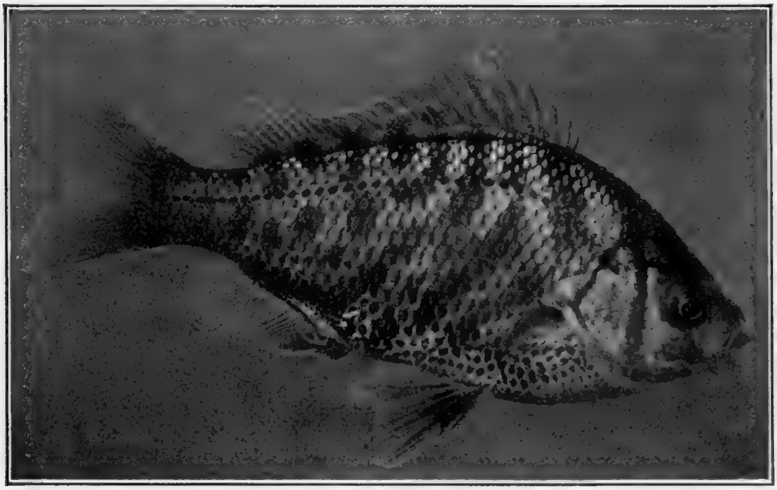


Fig. 312.—Viviparous Perch (male), *Hysterocarpus traski* Gibbons. Battle Creek, Sacramento River. (Photograph by Cloudsley Rutter.)

adults differ markedly in coloration, the young have the same dress, light yellowish olive with deeper and brighter transverse bands, something like the young trout and salmon in their parr dress."

CHAPTER XXII

CHROMIDES AND PHARYNGOGNATHI

SUBORDER Chromides.—The suborder *Chromides* contains spiny-rayed fishes similar to the perch-like forms in most regards, but strikingly distinguished by the complete union of the lower pharyngeal bones, as in the *Holconoti* and *Pharyngognathi*, and still more remarkably by the presence of but one nasal opening on each side. In all the perch-like fishes and in nearly all others there are two nasal openings or nostrils on each side, these two entering into the same nasal sac. In all the *Chromides* the lateral line is incomplete or interrupted, and the scales are usually large and ctenoid.

The Cichlidæ.—The suborder *Chromides* includes two families, *Cichlidæ*, and *Pomacentridæ*. The *Cichlidæ* are fresh-water fishes of the tropics, characterized by the presence of three to ten spines in the anal fin. In size, color, appearance, habits, and food value they bear a striking resemblance to the fresh-water sunfishes, or *Centrarchidæ*, of the eastern United States. This resemblance is one of analogy only, for in structure the *Cichlidæ* have no more in common with the *Centrarchidæ* than with other families of perch or bass. The numerous species of *Cichlidæ* are confined to tropical America and to corresponding districts in Africa and western Asia. *Tilapia nilotica* abounds in the Nile. *Tilapia galilæa* is found in the river Jordan and the Lake of Galilee. This species is supposed to form part of the great draught of fishes recorded in the Gospels, and a black spot on the side is held to commemorate the touch of Simon Peter. Numerous other species of *Cichlidæ*, large and small, abound in central Africa, even in the salt ditches of the Sahara.

The species of *Cichla*, especially *Cichla ocellaris*, of the rivers of South America, elongate and large-mouthed, bear a strong

analogy to the black bass of farther north. A vast number of species belonging to *Heros*, *Acara*, *Cichlasoma*, *Geophagus*, *Chætobranchus*, and related genera swarm in the Amazon region. Each of the large rivers of Mexico has one or more species; one of these, *Heros cyanoguttatus*, occurs in the Rio Grande and the rivers of southern Texas, its range corresponding with that of *Tetragonopterus argentatus*, just as the range of the whole family of *Cichlidæ* corresponds with that of the *Characinidæ*. No other species of either family enters the United States. A similar species, *Heros tetracanthus*, abounds in the rivers of Cuba, and another, *Heros beani*, called the mojarra verde, in the streams of Sinaloa. In the lakes and swamps of Central America *Cichlidæ* and *Characinidæ* are very abundant. One fossil genus is known, called *Priscacara* by Cope. *Priscacara clivosa* and other species occur in the Eocene of Green River and the Great Basin of Utah. In this genus vomerine teeth are said to be present, and there are three anal spines. None of the living *Cichlidæ* have vomerine teeth.

The Damsel-fishes: Pomacentridæ.—The *Pomacentridæ*, called rock-pilots or damsel-fishes, are exclusively marine and have in all cases but two anal spines. The species are often very brilliantly colored, lustrous metallic blue and orange or scarlet being the prevailing shades among the bright-colored species. Their habits in the reef pools correspond very closely with those of the *Chætodontidæ*. With the rock-pilots, as with the butterfly-fishes, the exceeding alertness and quickness of movement make up for lack of protective colors. With both groups the choice of rocky basins, crevices in the coral, and holes in coral reefs preserves them from attacks of enemies large enough to destroy them. In Samoa the interstices in masses of living coral are often filled with these gorgeous little fishes. The *Pomacentridæ* are chiefly confined to the coral reefs, few ranging to the northward of the Tropic of Cancer. Sometimes the young are colored differently from the adult, having sky-blue spots and often ocelli on the fins, which disappear with age. But one species *Chromis chromis*, is found in the Mediterranean. *Chromis punctipinnis*, the blacksmith, is found in southern California, and *Chromis notatus* is the common dogoro of Japan. One of the largest species, reaching the length of a foot, is the Gari-

baldi, *Hypsypops rubicundus*, of the rocky shores of southern California. This fish, when full grown, is of a pure bright

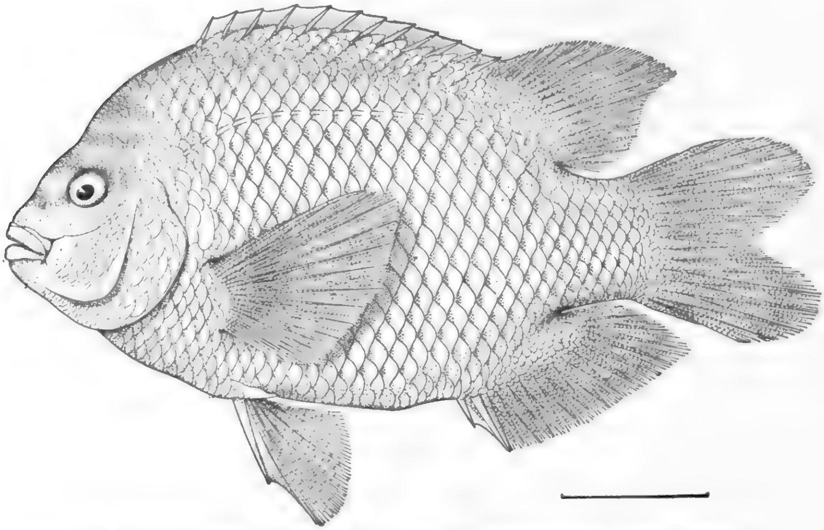


FIG. 313.—Garibaldi (scarlet in color), *Hypsypops rubicunda* (Girard). La Jolla, San Diego, Cal.

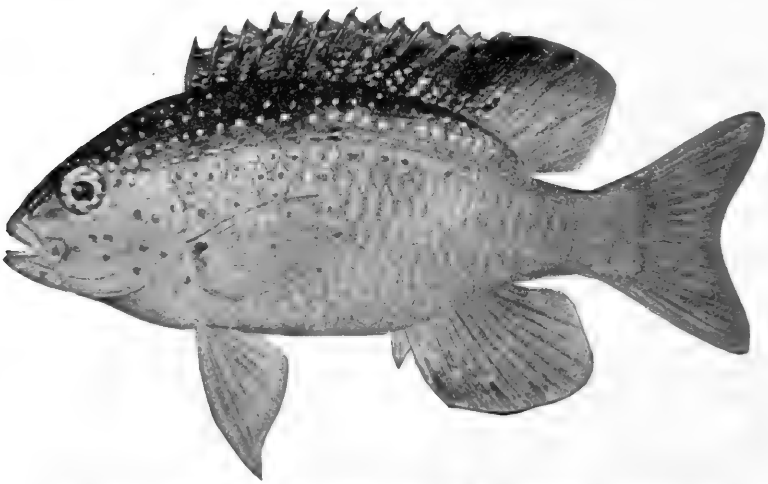


FIG. 314.—*Pomacentrus leucostictus* (Müller & Troschel), Damsel-fish. Family *Pomacentridæ*.

scarlet. The young are greenish, marked with blue spots. Species of *Pomacentrus*, locally known as pescadö azul, abound

in the West Indies and on the west coast of Mexico. *Pomacentrus fuscus* is the commonest West Indian species, and *Pomacentrus rectifrenum* the most abundant on the west coast of Mexico, the young, of an exquisite sky-blue, crowding the rock pools. *Pomacentrus* of many species, blue, scarlet, black, and golden, abound in Polynesia, and no rock pool in the East Indies is without several forms of this type. The type reaches its greatest development in the south seas. About forty different species of *Pomacentrus* and *Glyphisodon* occur in the corals of the harbor of Apia in Samoa.

Almost equally abundant are the species of *Glyphisodon*. The "cockeye pilot," or jaqueta, *Glyphisodon marginatus*, green with

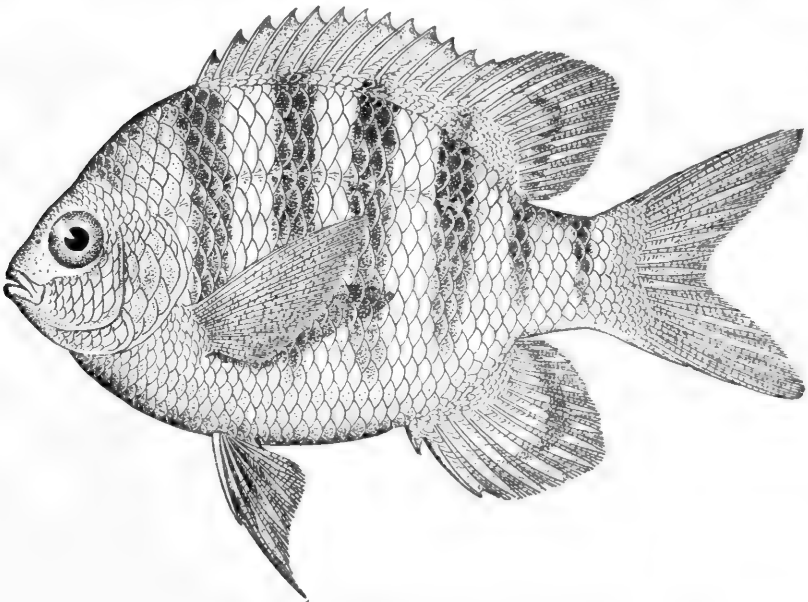


FIG. 315.—Cockeye Pilot, *Glyphisodon marginatus* (Bloch). Cuba.

black bands, swarms in the West Indies, occasionally ranging northward, and is equally common on the west coast of Mexico. *Glyphisodon abdominalis* replaces it in Hawaii, and the Asiatic *Glyphisodon saxatilis* is perhaps the parent of both. *Glyphisodon sordidus* banded with pale and with a black ocellus below the soft dorsal is very common from Hawaii to the Red Sea, and is a food-fish of some importance. *Glyphisodon cœlestinus* blue, with black bands, abounds in the south seas.

The many species of *Amphiprion* are always brilliant, red or orange, usually marked by one or two cross-bands of creamy blue. *Amphiprion melanopus* abounds in the south seas. *Azurina hirundo* is a slender species of lower California of a brilliant metallic blue. All these species are carnivorous, feeding on shrimps, worms, and the like.

Microspathodon is herbivorous, the serrated incisors being loosely implanted in the jaws. *Microspathodon dorsalis*, of the west coast of Mexico, is of a deep indigo-blue color, with streamer-like fins. *Microspathodon chrysurus*, of the West Indian coral reefs, black with round blue spots and the tail yellow. This

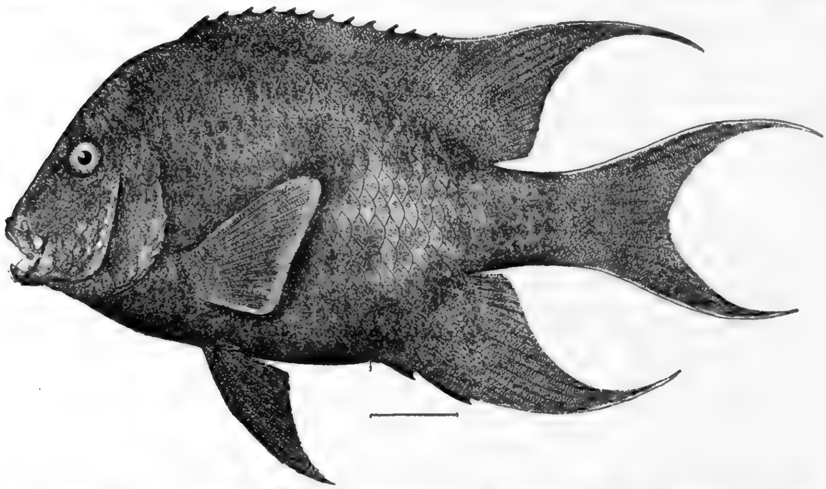


Fig. 316.—Indigo Damsel fish, *Microspathodon dorsalis* (Gill). Mazatlan, Mex.

family is probably of recent origin, as few fossils are referred to it. *Odonteus pygmæus* of the Eocene perhaps belongs to it.

Suborder Pharyngognathi.—The wrasses and parrot-fishes, constituting the group called *Pharyngognathi* (φαρύγξ, gullet; γνάθος, jaw), by Johannes Müller, have the lower pharyngeal bones much enlarged and solidly united, their teeth being either rounded or else flat and paved. The nostrils, ventral fins, pectoral fins and shoulder-girdle are of the ordinary perch-like type. The teeth are, however, highly specialized, usually large and canine-like, developed in the jaws only, and the gills are reduced in number, $3\frac{1}{2}$ instead of 4, with no slit behind the last half gill. The scales are always cycloid and are usually large. In the tropical forms the vertebræ are always twenty-four in

number (10+14), but in northern forms the number is largely increased with a proportionate increase in the number and strength of the dorsal spines. All the species are strictly marine, and the coloration is often the most highly specialized and brilliant known among fishes, the predominant shade being blue.

All are carnivorous, feeding mainly on crustaceans and snails, which they crush with their strong teeth, there being often a strong canine at the posterior end of the premaxillary, which holds the snail while the lower jaw acts upon it. The species are very numerous and form the most conspicuous feature in the fish markets of every tropical port. They abound

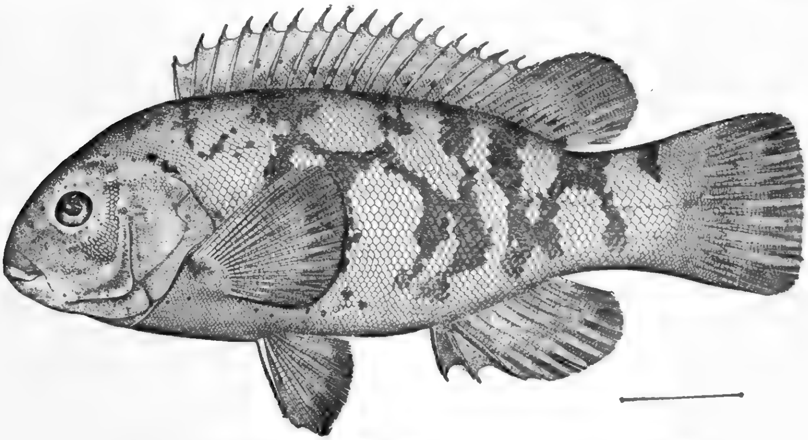


Fig. 317.—Tautog, *Tautoga onitis* (L.). Wood's Hole, Mass.

especially in the pools and openings in the coral reefs. All are good for food, though all are relatively flavorless, the flesh being rather soft and not oily.

The Wrasse Fishes: Labridæ.—The principal family is that of the *Labridæ*, characterized by the presence of separate teeth in the front of the jaws. Numerous fossil species are known from the Eocene and Miocene. Most of these are known only from the lower pharyngeal bones. *Labrodon* is the most widely diffused genus, probably allied to *Labrus*, but with a pile of successional teeth beneath each functional tooth. The species are mostly from the Miocene.

The northern forms of *Labridæ* are known as wrasse on the

FIG. 318.—Tautog, *Tautoga onitis* (L.). (From life by Dr. R. W. Shufeldt.)

coasts of England. Among these are *Labrus bergylta*, the ballan wrasse; *Labrus viridis*, the green wrasse; *Labrus ossiphagus*, the red wrasse; and *Labrus merula*, the black wrasse. *Acantholabrus palloni* and *Centrolabrus exoletus* have more than three anal spines. The latter species, known as rock cook, is abundant in western Norway, as far north as Throndhjem, its range extending to the northward beyond that of any other Labroid. Allied to these, on the American coast, is the tautog or blackfish, *Tautoga onitis*, a common food-fish, dusky in color with excellent white flesh, especially abundant on the coast of New England. With this, and still more abundant, is the cunner or chogset, *Tautogolabrus adspersus*, greenish-blue

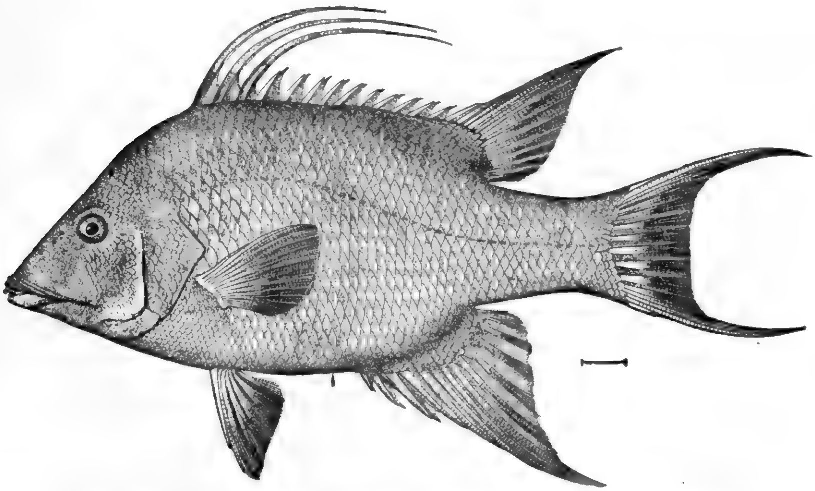


FIG. 319.—Capitaine or Hogfish, *Lachnolaimus falcatus*. Florida.

in color, the flesh being also more or less blue. This fish is too small to have much value as food, but it readily takes the hook set for better fishes.

In the Mediterranean are found many species of *Crenilabrus*, gaily colored, each species having its own peculiar pattern and its own arrangement of inky spots. Among these are *Crenilabrus mediterraneus*, *Crenilabrus pavo*, and *Crenilabrus griseus*. With these are the small species called *Ctenolabrus rupestris*, the goldsinny, much like the American cunner, and the long-nosed *Symphodus scina*.

Of the many West Indian species we may notice the Capi-

taine or hogfish, *Lachnolaimus maximus*, a great fish, crimson in color, with its fin spines ending in long streamers; *Bodianus rufus*, the Spanish lady-fish or pudiano, half crimson, half golden. *Halichœres radiatus*, the pudding-wife (a mysterious word derived from "oldwife" and the Portuguese name, pudiano), a blue fish handsomely mottled and streaked. Of the smaller species, *Clepticus parræ*, the janissary, with very small teeth, *Halichœres bivittatus*, the slippery-dick, ranging northward to Cape Hatteras, and *Doratonotus megalepis*, of an intense grass-green color, are among the most notable. The razor-fish, *Xyrichthys psittacus*, red, with the forehead compressed to a sharp edge, is found in the Mediterranean as well as throughout the West Indies, where several other species of razor-fish also occur.

Scarcely less numerous are the species of the Pacific Coast of America. *Pimelometopon pulcher*, the redfish or fathead of

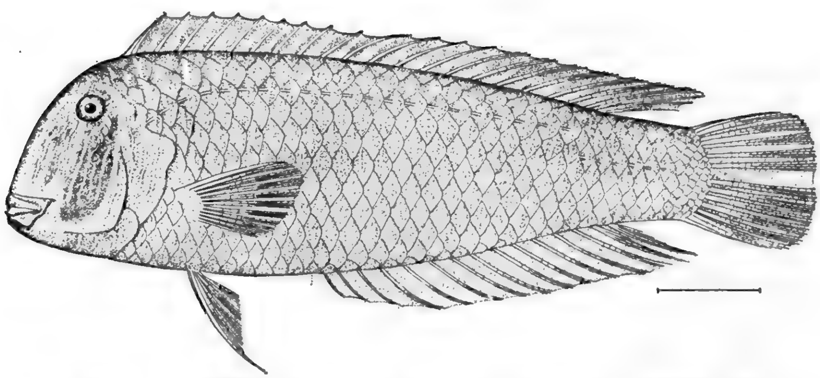


FIG. 320.—Razor-fish, *Xyrichthys psittacus* (Linnæus). Tortugas, Fla.

southern California, reaches a length of two feet or more. It abounds in the broad band of giant kelp which lines the California coast and is a food-fish of much importance. The female is dull crimson. In the male the head and tail are black and on the top of the head is developed with age a great adipose hump. A similar hump is found on the adult of several other large labroids. Similar species on the coast of South America, differing in color and size of scales, are *Pimelometopon darwini*, *Trochocopus opercularis*, and *Bodianus diplotænia*. The señorita, *Oxyjulis californica*, is a dainty cream-colored little fish

of the California coast, *Halichœres semicinctus*, the kelpfish, light olive, the male with a blue shoulder bar, is found in southern California. On the west coast of Mexico are numerous species of *Thalassoma*, *Halichœres*, *Pseudojulis*, *Xyrichthys* and *Iniistius*, all different from the corresponding species in the West Indies, and equally different from the much greater

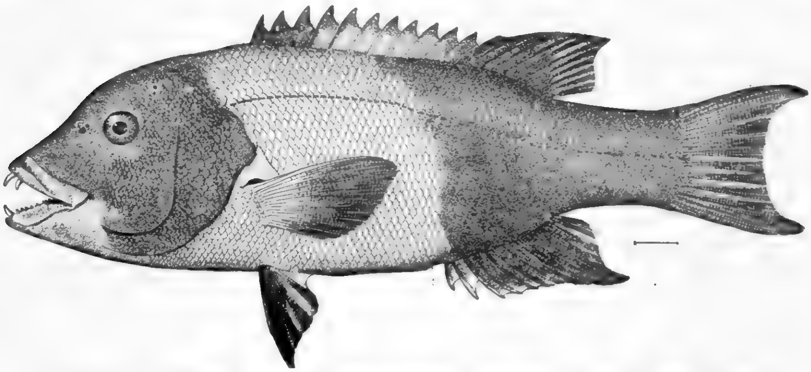


FIG. 321.—Redfish (male), *Pimelometopon pulcher* (Ayres). San Diego.

variety found in Hawaii and in Samoa. About the Polynesian and West Indian islands abound a marvelous wealth of forms of

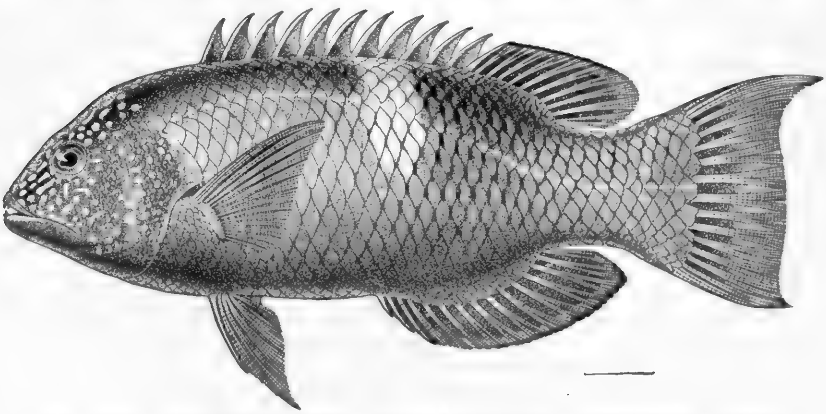


FIG. 322.—*Lepidaplois perditio* (Quoy & Gaimard). Wakanoura, Japan.

every shade and pattern of bright colors—blue, green, golden, scarlet, crimson, purple—as if painted on with lavish hand and often in the most gaudy pattern, although at times laid on with the greatest delicacy. The most brilliant species belong to *Thalassoma* and *Julis*, the most delicately colored to *Stetho-*

julis and *Cirrhilabrus*. In *Gomphosus* the snout is prolonged on a long slender tube. In *Cheilio* the whole body is elongate. In *Iniistius* the first two dorsal spines form a separate fin, the forehead being sharp as in *Xyrichthys*. Other widely distributed genera are *Anampses*, *Lepidaplois*, *Semicossyphus*, *Duymæria*, *Platyglossus*, *Pseudolabrus*, *Hologymnosus*, *Macropharyngodon*, *Coris*, *Julis*, *Hemipteronotus*, *Novaculichthys*, *Cheilinus*, *Hemigymnus*, and *Cymolutes*. *Halichœres* is as abundant in the East Indies as in the West, one of its species *Halichœres pœcilopterus* being common as far north as Hakodate in Japan. In this species as in a few others the sexes are very different in color, although in most species no external sexual differences of any sort appear. In the East Indian genus, *Pseudocheilinus*, the eye is very greatly modified. The cornea is thickened, forming two additional lens-like structures.

The small family of *Odacidæ* differs from the *Labridæ* in having in each jaw a sharp cutting edge without distinct teeth anteriorly, the pharyngeal teeth being pavement-like. The scales are small, very much smaller than in the *Scaridæ*, the body more elongate, and the structure of the teeth different. The species are mostly Australian, *Odax balteatus* being the most abundant. It is locally known as kelpfish.

In the *Siphonognathidæ* the teeth are much as in the *Odacidæ*, but the body is very elongate, the snout produced as in the cornet-fishes (*Fistularia*), and the upper jaw ends in a long skinny appendage. *Siphonognathus argyrophanes*, from Australia, reaches a length of sixteen inches.

The Parrot-fishes: Scaridæ.—The parrot-fishes, or *Scaridæ*, are very similar to the *Labridæ* in form, color, and scales, but differ in the more or less complete fusion of the teeth, a character which varies in the different genera.

Of these the most primitive is *Calotomus*, confined to the East Indies and Polynesia. In this genus the teeth are united at base, their tips free and imbricated over the surface of the jaw.

The species are dull in color, reddish or greenish. *Calotomus japonicus* is the Budai or Igami of Japan. *Calotomus sandwichensis* and *Calotomus irradians* are found in Hawaii, and *Calotomus xenodon* on the offshore islands of Mexico.

In *Calotomus* the dorsal spines are slender. In *Scaridea* (*balia*) of the Hawaiian Islands the first dorsal is formed of pungent spines as in *Sparisoma*.

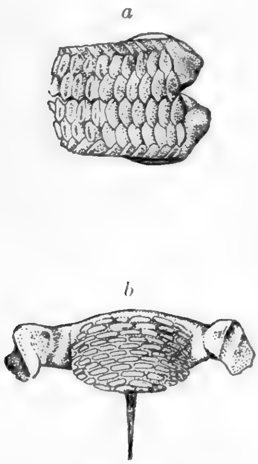


Fig. 323.

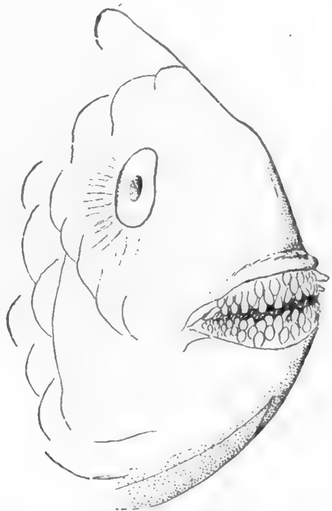


Fig. 324.

Fig. 323.—Pharyngeals of Italian Parrot-fish, *Sparisoma cretense* (L.). *a*, upper; *b*, lower.
Fig. 324.—Jaws of a Parrot-fish, *Calotomus xenodon* Gilbert.

Cryptotomus of the Atlantic is also a transitional group having the general characters of *Sparisoma*, but the anterior

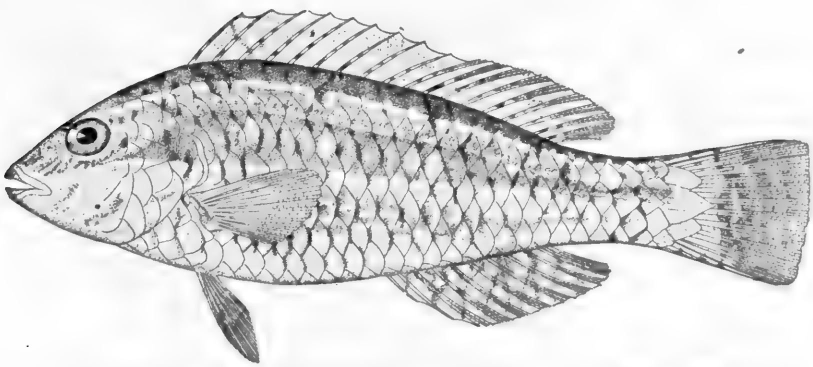


Fig. 325.—*Cryptotomus beryllinus* Jordan & Swain. Key West, Florida.

teeth more separate. The several species are all small and characteristic of the West Indian fauna, one species, *Cryptotomus beryllinus*, ranging northward to Long Island.

In the large genus *Sparisoma* the teeth are more completely joined. In this group, which is found only in the tropical Atlantic, the lower pharyngeals are broader than long and

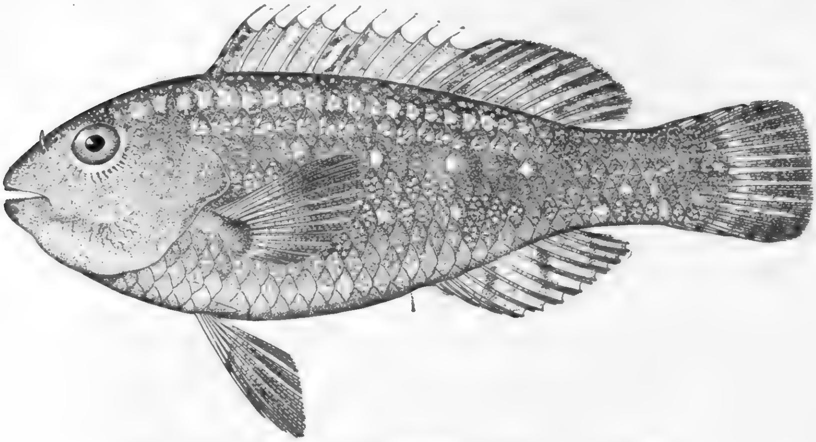


FIG. 326.—*Sparisoma hoplomystax* (Cope). Key West.

hexagonal. The teeth of the jaws are not completely united, the dorsal spines are pungent, the lateral line not interrupted, and the gill membranes broadly united to the isthmus.

Of the numerous species the dull-colored *Sparisoma flaves-*

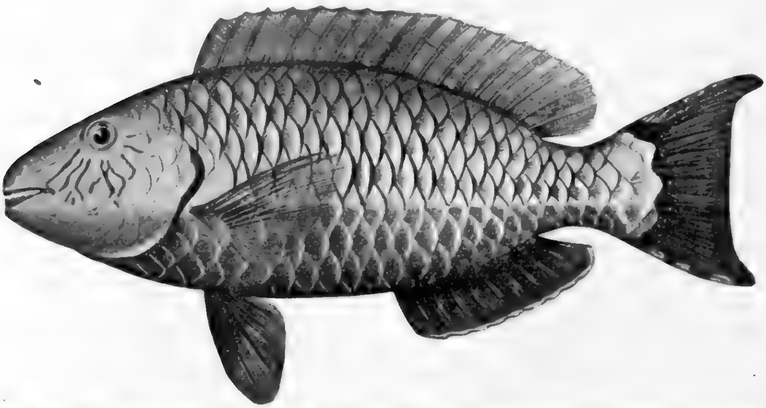


FIG. 327.—*Sparisoma abildgaardi* (Bloch), Red Parrot-fish. Loro, Colorado. Family *Scaridæ*.

cens is most abundant in the West Indies and ranges farther north than any other. *Sparisoma cretense*, the *Scarus* of the

ancients, is found in the Mediterranean, being the only member of the family known in Europe and the only *Sparisoma* known from outside the West Indian fauna.

Other West Indian species are the red parrot-fish, *Sparisoma abildgaardi*, *Sparisoma xystrodon*, *Sparisoma hoplomystax*, the last two being small species about the Florida Keys, and the handsome *Sparisoma viride* from the West Indies.

Scarus is the great central genus of parrot-fishes. Its members are especially abundant in Polynesia and the East Indies, the center of distribution of the group, although some extend their range to western Mexico, Japan, the Red Sea, and Australia, and a large number are found in the West Indies. Most of them are fishes of large size, but a few, as the West Indian *Scarus croicensis*, reach the length of less than a foot, and other still smaller species (*Scarus evermanni*, *Scarus bollmani*) are found only in water of considerable depth (200 fathoms).

FIG. 328.—Jaws of Blue Parrot-fish, *Scarus cæruleus* (Bloch).

The genus *Scarus* is characterized by not only the almost complete fusion of its teeth, but by numerous other characters. Its lower pharyngeals are oblong and spoon-shaped, the teeth appearing as a mosaic on the concave surface. The gill-membranes are scarcely united to the narrow isthmus, the lateral line is interrupted, the dorsal spines are flexible, and there

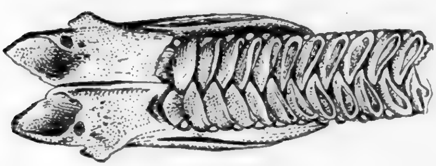


FIG. 329.

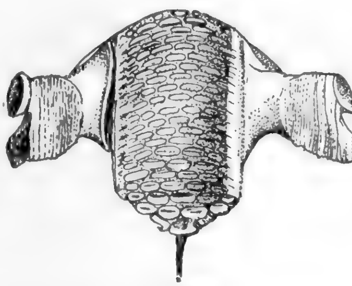


FIG. 330.

FIG. 329.—Upper pharyngeals of an Indian Parrot-fish, *Scarus strongylocephalus*.
FIG. 330.—Lower pharyngeals of a Parrot-fish, *Scarus strongylocephalus* (Bleeker).

are but few scales on the head. These, as well as the scales of the body, are always large. The most highly specialized

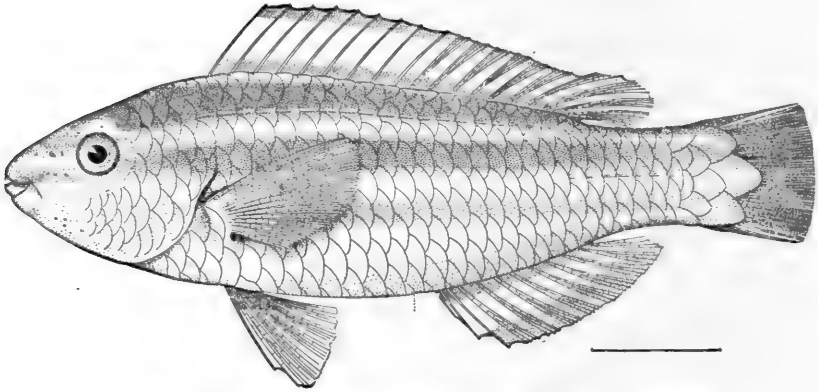


FIG. 331.—*Scarus emblematicus* Jordan & Rutter. Jamaica.

of its species have the teeth deep blue in color, a character which marks the genus or subgenus *Pseudoscarus*. Of the species of this type, the loro, *Pseudoscarus cælestinus*, and the more abundant guacamaia, *Pseudoscarus guacamaia* (fig. 215 vol. I) of the West Indies, are characteristic forms. The perrico, *Pseudo-*

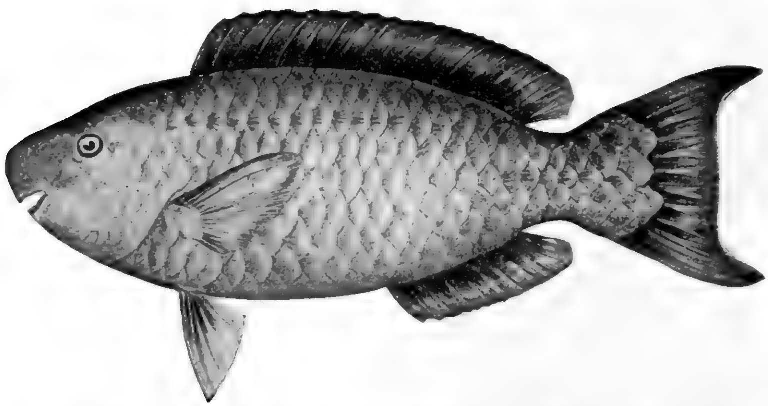


FIG. 332.—*Scarus cæruleus* (Bloch). Blue Parrot-fish. Loro, Azul. Family *Scaridæ*.

scarus perrico of the west coast of Mexico, and the great blue parrot-fish, or galo, of Hawaii and Samoa, *Pseudoscarus jordani*, belong to this type. *Pseudoscarus jordani* was formerly tabu to the king in Hawaii, and its brilliant colors and toothsome

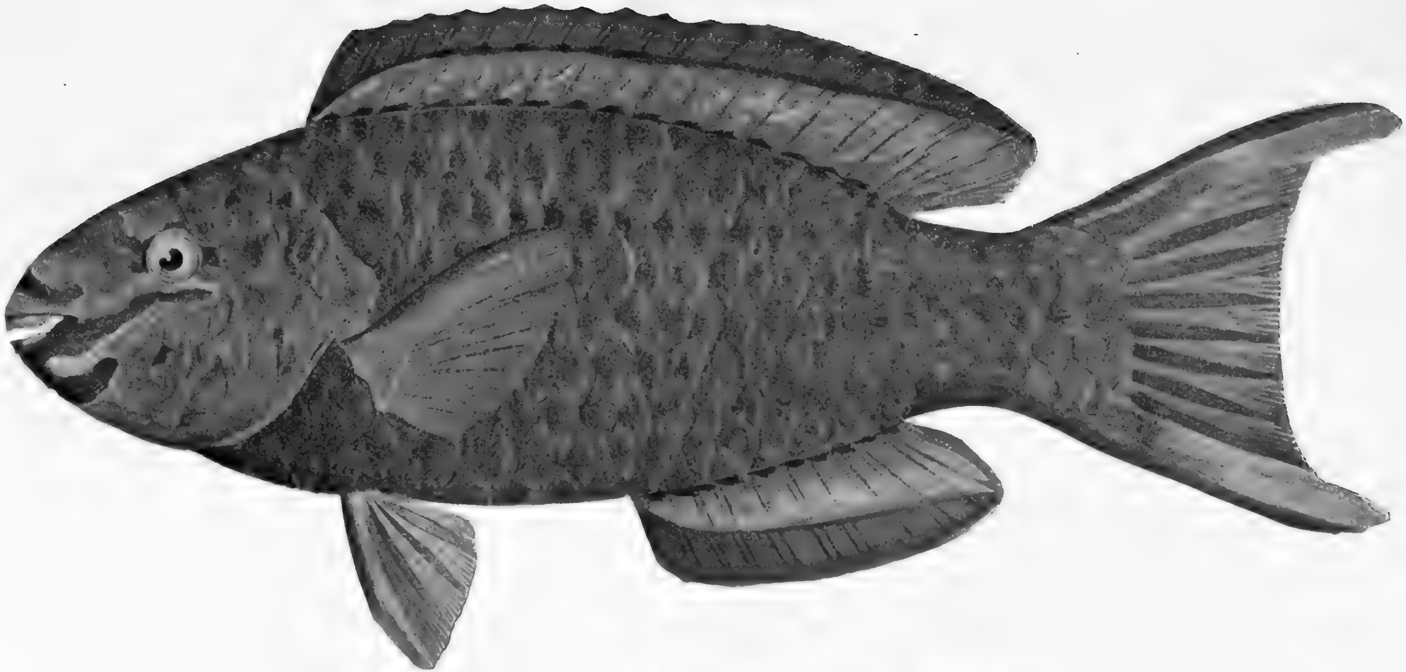


FIG. 333.—*Scarus vetula* Bloch & Schneider, Parrot-fish. Family *Scaridæ*.

flesh (when eaten raw) made it the most highly valued fish at the royal banquets of old Hawaii. It still sells readily at a dollar or more per pound. To this type belong also the blue parrot-fish, *Pseudoscarus ovifrons*, of Japan. In the restricted genus *Scarus* proper the teeth are pale. The great blue parrot-fish, of the West Indies, *Scarus cæruleus*, belongs to this group. This species, deep blue in color, reaches a large size, and the adult has a large fleshy hump on the forehead. Lesser parrot-fish with pale teeth and with showy coloration are the West Indian species *Scarus tæniopterus*, *Scarus vetula*, *Scarus croicensis*, etc.

Very many species of both *Scarus* and *Pseudoscarus*, green, blue, red-brown, or variegated, abound about the coral reefs of Polynesia. About twenty-five species occur in Samoa.

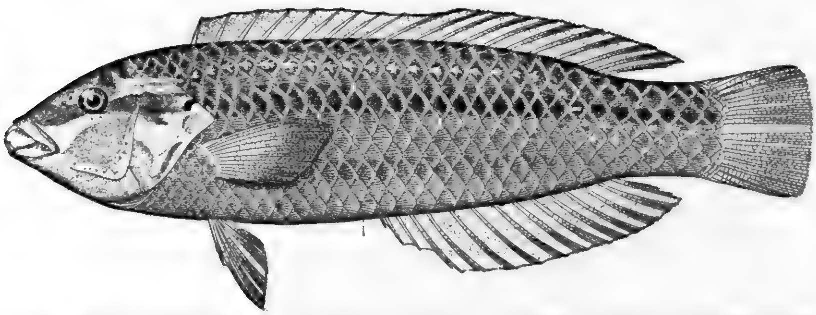


FIG. 334.—Slippery-dick or Doncella, *Halichœres bivittatus* (Bloch), a fish of the coral reefs, Key West. Family *Labridæ*.

Pseudoscarus latax and *P. ultramarinus* being large and showy species, chiefly blue. *Pseudoscarus prasiognathus* is deep red with the jaws bright blue.

Fossil species referred to *Scarus* but belonging rather to *Sparisoma* are found in the later Tertiary. The genera *Phyllodus*, *Egertonia*, and *Paraphyllodus* of the Eocene perhaps form a transition from *Labridæ* to *Scaridæ*. In *Paraphyllodus medius* the three median teeth of the lower pharyngeals are greatly widened, extending across the surface of the bone.

CHAPTER XXIII

THE SQUAMIPINNES

THE **Squamipinnes.** — Very closely allied to the *Percomorphi* is the great group called *Squamipinnes* (*squama*, scale; *pinna*, fin) by Cuvier and *Epelasmia* by Cope. With a general agreement with the *Percomorphi*, it is distinguished by the more or less complete soldering of the post-temporal with the cranium. In the more specialized forms we find also a soldering of the elements of the upper

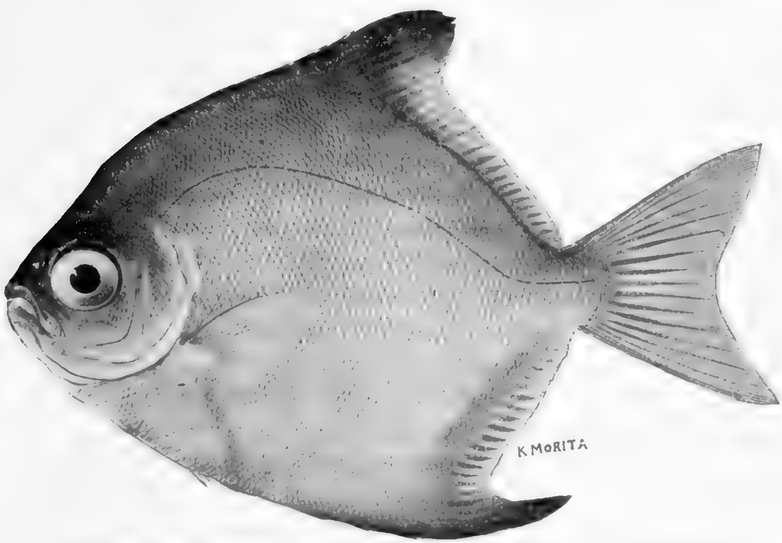


FIG. 335.—*Monodactylus argenteus* (Linnæus). From Apia, Samoa. Family *Scorpididæ*.

jaw, and a progressive reduction in the size of the gill-opening. The ventral fin retains its thoracic insertion, and, as in the perch mackerel-like forms, it has one spine and five rays, never any more. The ventral fins are occasionally lost in the adult,

as in the *Stromateidæ*, or they may lose part of their rays. The name *Squamipinnes* refers to the scaly fins, the typical species having the soft rays of dorsal, anal, and caudal, and sometimes of other fins densely covered with small scales. In various aberrant forms these scales are absent. The name *Epelasmia* (ἔπι, above; ἐλάσμος, plate) refers to the thin upper pharyngeals characteristic of certain forms. The transition from this group to the *Sclerodermi* is very clear and very gradual. The *Squamipinnes*, *Sclerodermi*, *Ostracodermi*, and *Gymnodontes* form a continuous degenerating series. On the other hand the less specialized *Squamipinnes* approach very closely to forms already considered. The *Antigoniidæ* are of uncertain affinities, possibly derived from such forms as *Histiopteridæ*, while *Platax* show considerable resemblance to scaly-finned fishes like the *Kyphosidæ* and *Stromateidæ*. The *Scorpididæ* seem intermediate between *Stromateidæ* and *Platacidæ*. In such offshoots from *Scombroidei* or *Percoidei* the group doubtless had its origin.

We may begin the series with some forms which are of doubtful affinity and more or less intermediate between the *Squamipinnes* and the more primitive *Percomorphi*.

The Scorpididæ.—This family has the general appearance of *Platax* and *Ilarches*, but the teeth are not brush-like, and the post-temporal is free from the skull as in perch-like fishes. The species inhabit the Pacific. *Scorpis georgianus* is a food-fish of Australia, with the body oblong. *Monodactylus argenteus*, the toto of Samoa, is almost orbicular in form, while *Psettus sebæ* is twice as deep as long, the deepest-bodied of all fishes in proportion to its length.

The Boarfishes: Antigoniidæ.—The boarfishes (*Antigoniidæ*) are characterized by a very deep body covered with rough scales, the post-temporal, as in the *Chætodontidæ* and the *Zeidæ*, being adnate to the skull.

These fishes bear some resemblance to *Zeus*, but there is no evidence of close affinity nor is it clear that they are related to the *Chætodontidæ*. *Capros aper*, the boarfish, is common in southern Europe, reaching a length of less than a foot, the protractile mouth suggesting that of a pig. The diamond-fishes, *Antigonia*, are deeper than long and strongly compressed, the body being covered with roughish scales. The color is

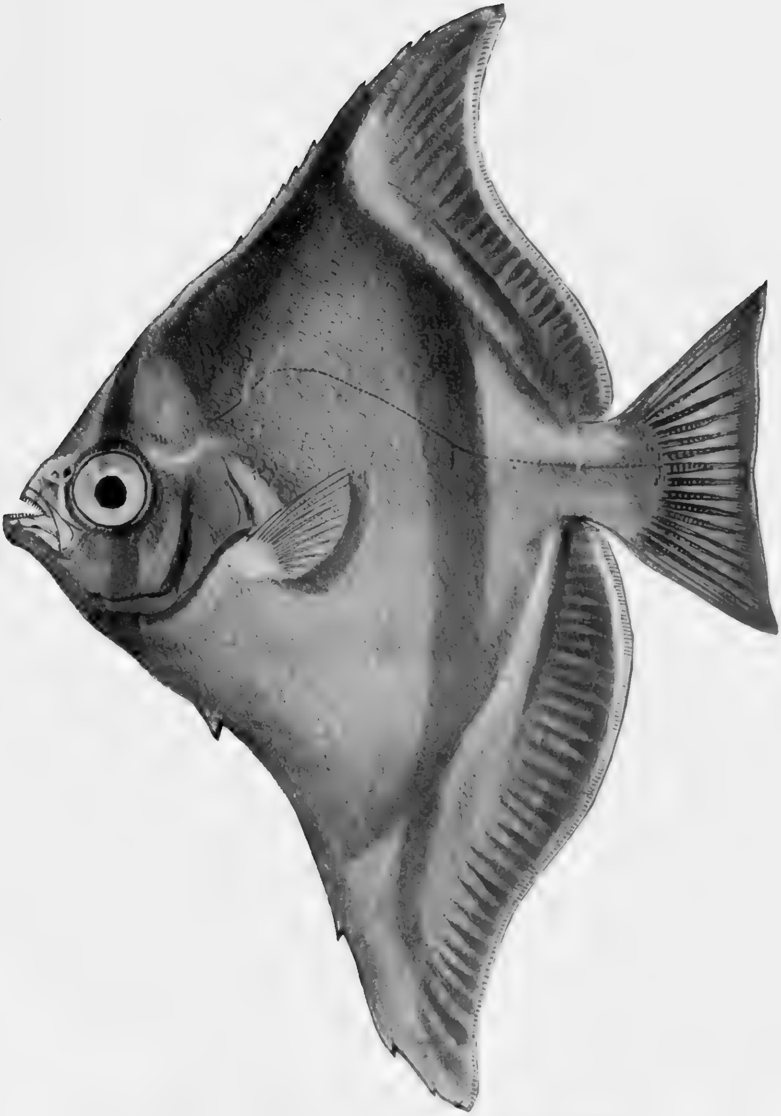


FIG. 336.—*Psettus sebæ* Cuv. & Val. East Indies.

salmon-red and the species live just below the depths ordinarily explored by fishermen. *Antigonia capros* is found at Madeira and in the West Indies, *Antigonia steindachneri* about Hawaii and in Japan, while the smaller *Antigonia rubescens* is abundant in the Japanese bays at a depth reached by the dredge. An extinct genus, *Proantigonia* from the Miocene is said to connect *Antigonia* with *Capros*.

The Arches: Toxotidæ.—The archers, *Toxotidæ*, have the body compressed, the snout produced, and the dorsal fin with but five spines. The skeleton differs widely from that of *Chætodon* and the family should perhaps rather find its place among the percoids. *Toxotes jaculatrix* is found in the East Indies. The name alludes to its supposed habit of catching insects by shooting drops of water at them through its long mouth.

The Ephippidæ.—With the typical *Squamipinnes*, the teeth become very slender, crowded in brush-like bands. The least specialized family is that of *Ephippidæ*, characterized by the presence of four anal spines and a recumbent spine before the dorsal. The principal genus, *Ephippus* (*Scatophagus*), is represented by *Ephippus argus*, a small, bass-like fish, spotted with black, found in the Indian seas, and ranging northward to Formosa. Species referred to *Ephippus* (*Scatophagus*) are recorded from the Italian Eocene of Monte Bolca, where a species of *Toxotes* has been also found.

The Spadefishes: Ilarchidæ. — In the *Ilarchidæ* the dorsal is divided into two fins, the spinous part being free from scales. In various regards the species are intermediate between ordinary perch-like forms and the chætodonts. In these fishes the body is very deep and, with the soft fins, closely covered with roughish scales. In *Ilarches* (*Ephippus*), represented by *Ilarches orbis* of the Indian seas, these scales are relatively large. This species is a common food-fish from India to Formosa.

In the American genus, *Chætodipterus*, the scales are quite small. The spadefish (*Chætodipterus faber*), sometimes called also moonfish or angel-fish, is a large, deep-bodied fish, reaching a length of two feet. It is rather common from Cape Cod to Cuba, and is an excellent pan fish, with finely flavored white flesh. The young are marked by black cross-bands which disappear with age, and in the adult the supraoccipital crest is greatly

thickened and the skull otherwise modified. A very similar species, *Chætodipterus zonatus*, occurs on the west coast of Mexico. Species allied to *Chætodipterus* are fossil in the Italian Eocene. The *Drepanidæ* of the East Indies are close to the *Ilarchidæ*. *Drepane punctata* is a large, deep-bodied fish resembling the spadefish but with larger scales.

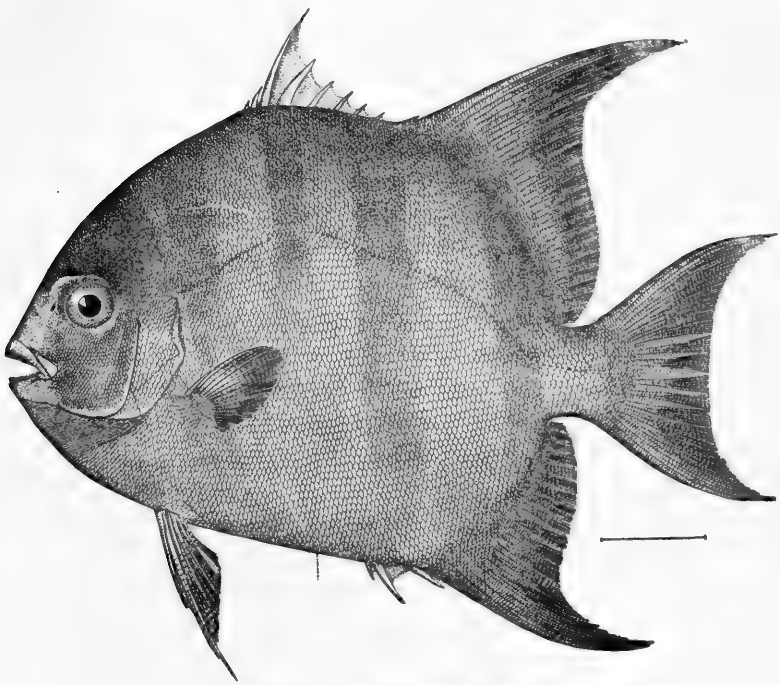


FIG. 337.—Spadefish, *Chætodipterus faber* (L.). Virginia.

The Platacidæ.—Closely related to the *Ilarchidæ* is also the East Indian family of *Platacidæ*, remarkable for the very great depth and compression of the body, which is much deeper than long, and the highly elevated dorsal and anal still further emphasize this peculiarity of form. In this group the few dorsal spines are closely attached to the soft rays and the general color is dusky. In the young the body is deeper than in the adult and the ventral fins much more produced. The best-known species is the tsuzume or batfish (*Platax orbicularis*), which ranges from India through the warm current to northern Japan. *Platax teira*, farther south, is very similar. *Platax*

altissimus, with a very high dorsal, is fossil in the Eocene of Monte Bolca.

The Butterfly-fishes: Chætodontidæ.—The central family of *Squamipinnes* is that of the butterfly-fishes or *Chætodontidæ*. In this group the teeth are distinctly brush-like, the mouth small, the dorsal fin continuous and closely scaly, and the ventral fins with one spine and five rays. The species are mostly of small size and brilliant and varied coloration, yellow and black being the leading colors. They vary considerably with age, the young having the posterior free edges of the bones of

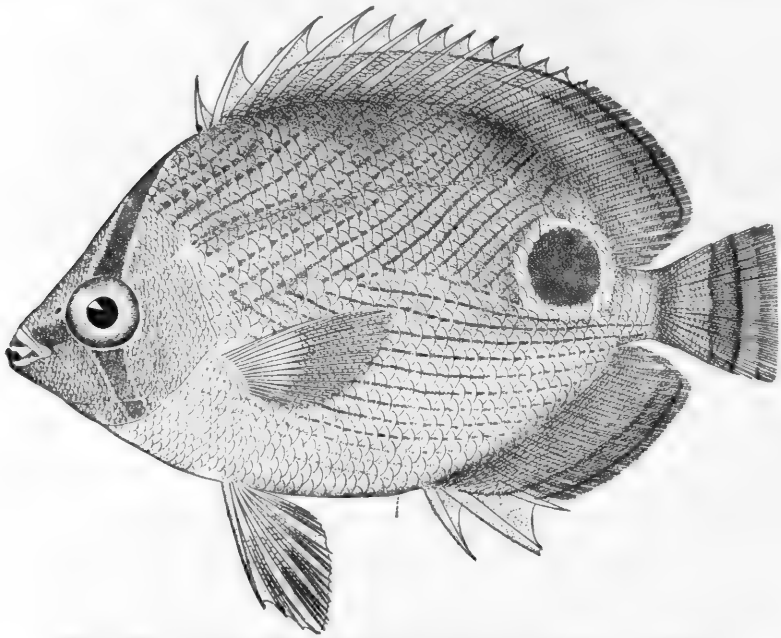


FIG. 338.—Butterfly-fish, *Chætodon capistratus* Linnæus. Jamaica.

the head produced, forming a sort of collar. These forms have received the name of *Tholichthys*, but that supposed genus is merely the young of *Chætodon*. The species of *Chætodontidæ* abound in rock pools and about coral reefs in clear water. They are among the most characteristic forms of these waters and their excessive quickness of movement compensates for their conspicuous coloration. In these confined localities they have, however, few enemies. The broad bodies and spinous fins make them rather difficult for a large fish to swallow. They feed

on small crustaceans, worms, and the like. The analogy to the butterfly is a striking one, giving rise to the English name, butterfly-fish, the Spanish mariposa, and the Japanese chocho-uwo, all having the same meaning. Fossil chætodonts are rather few, *Chætodon pseudorhombus* of the Pliocene of France, *Holocanthus microcephalus* and *Pomacanthus subarcuatus* of the Eocene, being the only species recorded by Zittel.

In the principal genus, *Chætodon*, the colors are especially

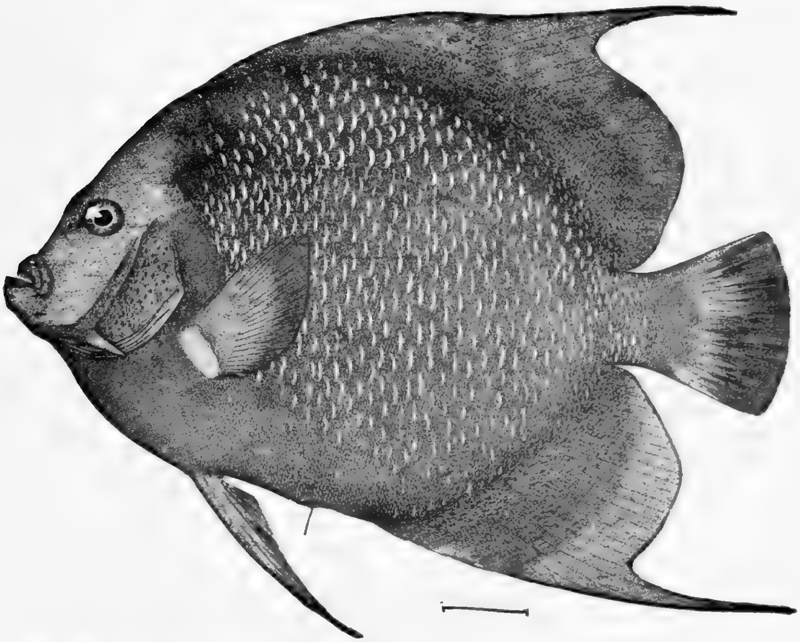


FIG. 339.—Black Angel-fish, *Pomacanthus arcuatus* (Linnæus). Barnegat, New Jersey.

bright. There is almost always a black bar across the eye, and often black ocelli adorn the fins. This genus is wanting in Europe. *Chætodon capistratus*, *striatus*, and numerous other species are found in the West Indies; *Chætodon humeralis* and *nigrirostris* are common on the coast of Mexico. The center of their distribution is in Polynesia and the East Indian Archipelago. *Chætodon reticulatus*, *lineolatus*, *ulietensis*, *ornatissimus*, *ephippion*, *setifer*, and *auriga* are among the most showy species. Numerous closely related genera are described. In some of these the snout is prolonged into a long tube, bearing

the jaws at its end. Of this type are *Chelmo* in India, *Forcipiger* in Polynesia, and *Prognathodes* in the West Indies. *Heniochus* (*macrolepidotus*) has one dorsal spine greatly elongated. *Microcanthus strigatus*, one of the most widely distributed species, is known by its small scales. *Megaprotodon* (*triangularis*) has four anal spines instead of three as in the others.

The species of *Holacanthus*, known as angel-fishes, are larger in size, and their colors are still more showy, being often scarlet or blue. In this genus the preopercle is armed with a strong

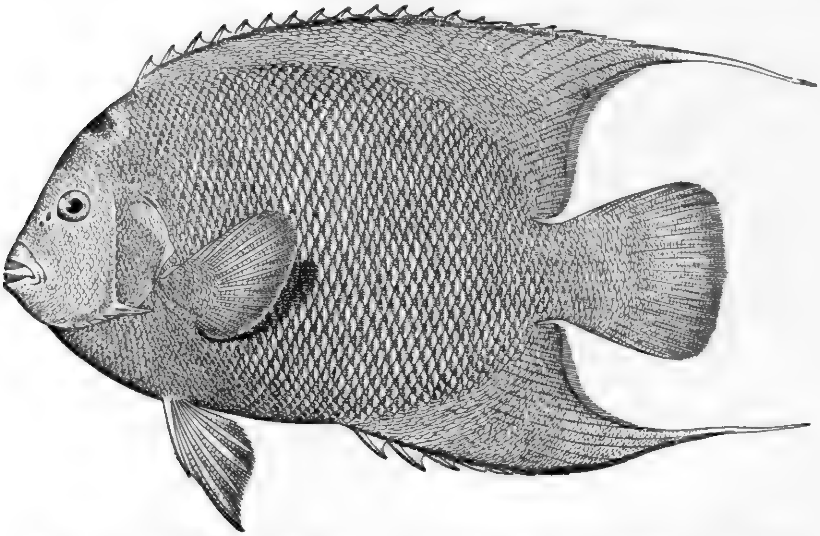


Fig. 340.—Angel-fish or Isabelita, *Holacanthus ciliaris* (Linnæus). Jamaica. Family *Chætodontidæ*.

spine, and there are fourteen or more strong spines in the dorsal. This genus has also its center of distribution in the East Indies, whence two species (*septentrionalis* and *ronin*) with concentric stripes of blue range northward to Japan. *Holacanthus tibicen*, jet-black with one yellow cross-band, is found from the Riu Kiu Islands southward. The angel-fish or isabelita (*Holacanthus ciliaris*), orange-red, sky-blue, and golden, as though gaudily painted, is the best-known species. The vaqueta de dos colores or rock beauty (*Holacanthus bicolor*), half jet-black, half golden, is scarcely less remarkable. Both are excellent food-fishes of the West Indies. *Holacanthus passer* is a showy inhabitant of the west coast of Mexico. *Holacanthus diacanthus*, orange, barred

with blue, is one of the gaudiest inhabitants of the coral reefs of Polynesia. *Holacanthus flavissimus*, golden with some deep-blue markings, and *Holacanthus nicobariensis*, blackish with white circles, are found with other species in the same waters.

The genus *Pomacanthus* (*Pomacanthodes*) includes American species only, still larger in size and differing from *Holacanthus* in having nine to eleven spines only in the dorsal fin. The young of *Pomacanthus* are blackish, crossed by many curved yellow cross-bands, which disappear entirely with age. Three species

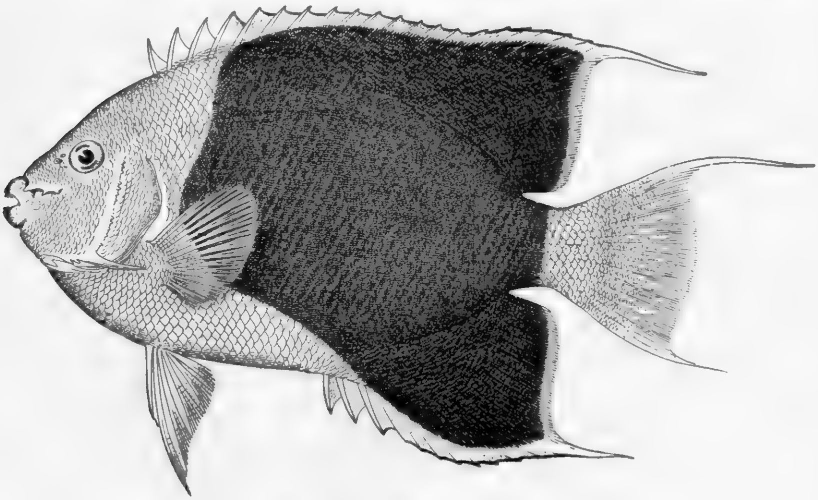


Fig. 341.—Rock Beauty, *Holacanthus tricolor* (L.). Puerto Rico.

are known, *Pomacanthus arcuatus*, the black angel, chirivita or portugais, *Pomacanthus paru*, the Indian-fish or paru of the West Indies, and *Pomacanthus zonipectus*, "Mojarra de las Piedras," of the west coast of Mexico. All are good food-fishes, but lacking the brilliant colors of *Holacanthus* and the fine pattern usual in *Chætodon*.

The Pygæidæ.—Between the *Chætodontidæ* and the *Acanthuridæ* we would place the extinct family of *Pygæidæ*, of the Eocene. In *Pygæus gigas* and other species the dorsal spines are strong and numerous; there are 5 to 8 species in the anal fin, the scales are shagreen-like, and the teeth seem coarser than in the *Chætodontidæ*. The tail is apparently unarmed, and the soft dorsal, as in *Chætodon*, is much shorter than the spinous. To this family

the Eocene genera, *Aulorhamphus* (*bolceusis*), with produced snout, and *Apostasis* (*croaticus*), with long spinous dorsal, probably belong.

The Moorish Idols: Zanclidæ. — The family of *Zanclidæ* includes a single species, the Moorish idol or kihi kihi, *Zanclus canescens*. In this family the scales are reduced to a fine sha-

Fig. 342.—The Moorish Idol, *Zanclus canescens* (Linnæus). From Hawaii. Family *Zanclidæ*. (Painting by Mrs. E. G. Norris.)

green, and in the adult two bony horns grow out over the eye. The dorsal spines are prolonged in filaments and the color is yellow crossed by bars of black. *Zanclus canescens* is a very handsome fish with the general appearance and habit of a *Chætodon*, but the form is more exaggerated. It is found throughout Polynesia, from Japan to the off-shore islands of

Mexico, and is generally common, though rarely entering rock pools.

Zanclus eocænus is recorded from the Italian Eocene.

The Tangs: Acanthuridæ.—In the next family, *Acanthuridæ*, the surgeon-fishes or tangs, the scales remain small and shagreen-like, the body is more elongate, the gill-openings still more restricted, and the teeth are flattened and incisor-like. The pubic bone is more elongate, and in all the species some sort of armature is developed on the side of the tail. The spinous dorsal

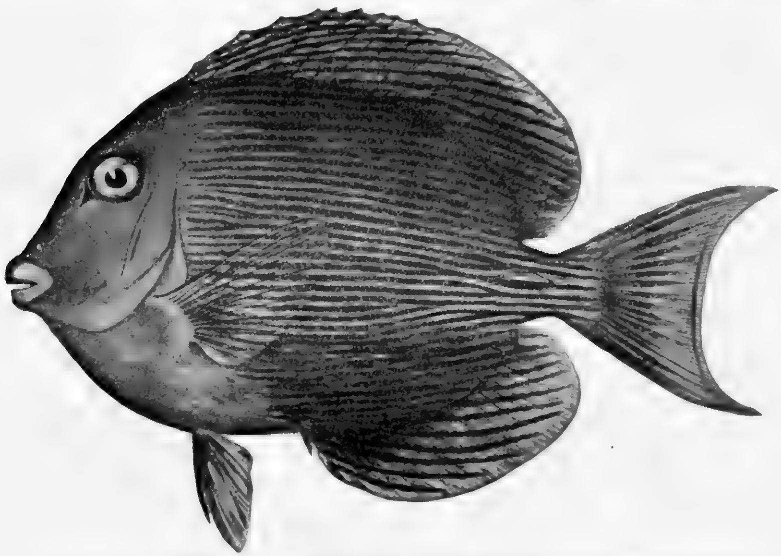


FIG. 343.—*Teuthis cæruleus* (Bloch & Schneider), Blue Tang; Medico. Family *Teuthididæ*.

in all is less developed than the soft dorsal. The species abound in the warm seas, especially about the tide pools, and are used as food. They undergo considerable changes with age, the caudal armature being developed by degrees. Nearly all are dull brown in color, but in some a vivid ornamentation is added. Fossil forms are found from the Eocene and later. Most of these are referable to *Teuthis* and *Acanthurus*.

The principal genus is *Teuthis*, characterized by the presence on each side of the tail of a sharp, knife-like, movable spine with the point turned forwards and dropping into a sheath. This spine gives these fishes their name of surgeon-fish, doctor-

fish, lancet-fish, tang, barbero, etc., and it forms a very effective weapon against fish or man who would seize one of these creatures by the tail. The species have the center of distribution in the East Indies and have not reached Europe. Three species are found in the West Indies. The blue tang (*Teuthis cœruleus*) is chiefly bright blue. The common tang, *Teuthis chirurgus*, is brown with bluish streaks, while a third species, *Teuthis bahianus*, has a forked caudal fin. Very close to this species is *Teuthis crestonis*, of the west coast of Mexico, and both are closely related to *Teuthis matoides*, found from India to Hawaii.

Teuthis triostegus, of Japan and Polynesia and the East Indies, is covered with cross-bands alternately black and pale.

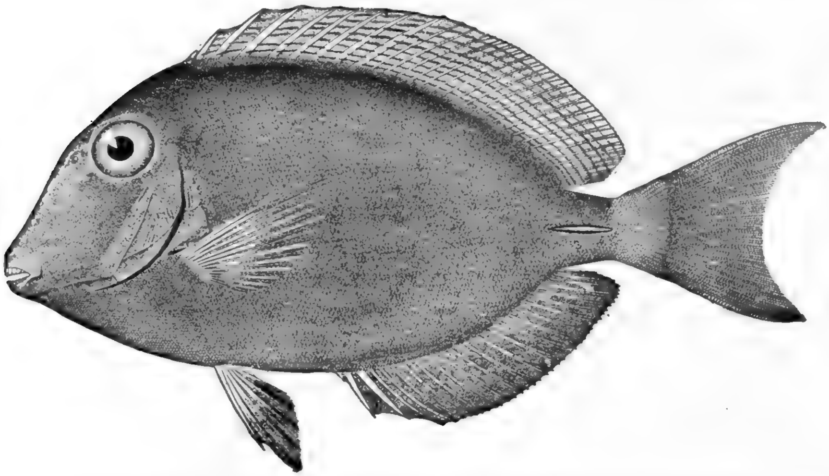


FIG. 344.—Brown Tang, *Teuthis bahianus* (Ranzani). Tortugas, Fla.

In Hawaii this is replaced by the very similar *Teuthis sandwichensis*. Many species are found about Hawaii and the other Polynesian Islands. *Teuthis achilles* has a large blotch of brilliant scarlet on the tail, and *Teuthis olivaceus* a bright-colored mark on the shoulder. *Teuthis lineatus*, yellow with blue stripes, a showily colored fish of the coral reefs, is often poisonous, its flesh producing ciguatera.

Zebrasoma differs from *Teuthis* in having but 4 or 5 dorsal spines instead of 10 or 11. In this genus the soft dorsal fin is very high. *Zebrasoma flavescens*, sometimes brown, sometimes bright

yellow, is common in Polynesia; *Zebrasoma veliferum*, cross-barred with black, is also common.

Ctenochætus (*strigosus*), unlike the others, is herbivorous and has its teeth loosely implanted in the gums. This species, black with dull orange streaks, was once tabu to the king of Hawaii, who ate it raw, and common people who appropriated it were put to death.

In *Xesurus* the caudal lancelet is replaced by three or four bony tubercles which have no sharp edge. *Xesurus scalprum* is common in Japan, and there are three species or more on the west coast of Mexico, *Xesurus punctatus* and *Xesurus laticlavius* being most abundant.

In *Prionurus* (*microlepidotus*) of the tropical Pacific the armature is still more degraded, about six small plates being developed.

In *Acanthurus* (*Monoceros, naseus*), the unicorn-fish and its relatives, the ventral fins are reduced, having but three soft rays, the caudal spines are very large, blunt, immovable, one placed in front of the other. In most of the species of *Acanthurus* a long, bony horn grows forward from the cranium above the eye. This is wanting in the young and has various degrees of development in the different species, in some of which it is wholly wanting. The species of *Acanthurus* reach a large size, and in some the caudal spines are bright scarlet, in others blue. *Acanthurus unicornis*, the unicorn-fish, is the commonest species and the one with the longest horn. It is abundant in Japan, in Hawaii, and in the East Indies.

Axinurus thynnoides of the East Indies has a long, slim body, with slender tail like a mackerel.

Suborder Amphacanthi, the Siganidæ. — The *Amphacanthi* (*ἄμφι*, everywhere; *ἄκανθα*, spine) are spiny-rayed fishes certainly related to the *Teuthididæ*, but differing from all other fishes in having the last ray of the ventrals spinous as well as the first, the formula being I, 4, I. The anal fin has also six or seven spines; and the maxillary is soldered to the premaxillary The skeleton is essentially like that of the *Acanthuridæ*.

The single family, *Siganidæ*, contains fishes of moderate size, valued as food, and abounding about rocks in shallow

water from the Red Sea to Tahiti. The coloration is rather plain olive or brown, sometimes with white spots, sometimes with bluish lines. The species are very much alike and all belong to the single genus *Siganus*. One species, *Siganus fuscescens*, dusky with small, pale dots, is a common food-fish of Japan. Others, as *Siganus oramin* and *Siganus vermiculatus*, occur in India, and *Siganus punctatus*, known as lo, abounds about the coral reefs of Samoa. *Siganus vulpinus* differs from the others in the elongate snout.

A fossil genus, *Archoteuthis* (*glaronensis*), is found in the Tertiary of Glarus. It differs from *Siganus* in the deeper body and in the presence of six instead of seven spines in the anal fin.

The real relationship of the *Siganidæ* is still uncertain, but the family is probably most nearly allied to the *Acanthuridæ*, with which the species were first combined by Linnæus, who included both in his genus *Teuthis*. In the structure of the vertical fins the *Siganidæ* resemble the extinct genus *Pygæus*.

CHAPTER XXIV

SERIES PLECTOGNATHI

THE Plectognaths.—Derived directly from the *Acanthuridæ*, from which they differ by progressive steps of degeneration, are the three suborders of *Sclerodermi*, *Ostracodermi*, and *Gymnodontes*, forming together the series or suborder of *Plectognathi*. As the members of this group differ from one another more widely than the highest or most generalized forms differ from the *Acanthuridæ*, we do not regard it as a distinct order. The forms included in it differ from the *Acanthuridæ* much as the swordfishes differ from ordinary mackerel. The *Plectognathi* (πλεκτός, woven together; γνάθος, jaw) agree in the union of the maxillary and premaxillary, in the union of the post-temporal with the skull, in the great reduction of the gill-opening, and in the elongation of the pelvic bones. All these characters in less degree are shown in the *Squamipinnes*. We have also the reduction and final entire loss of ventral fins, the reduction and loss of the spinous dorsal, the compression and final partial or total fusion of the teeth of the upper jaw, the specialization of the scales, which change from bony scutes into a solid coat of mail on the one hand, and on the other are reduced to thorns or prickles and are finally altogether lost. The number of vertebræ is also progressively reduced until in the extreme forms the caudal fin seems attached to the head, the body being apparently wanting. Throughout the group poisonous alkaloids are developed in the flesh. These may produce the violent disease known as ciguatera, directly attacking the nervous system. See p. 182, vol. I.

The three suborders of plectognathous are easily recognized by external characters. In the *Sclerodermi* (σκλερός, hard; δέρμα, skin) the spinous dorsal is present and the body is

more or less distinctly scaly. The teeth are separate and incisor-like and the form is compressed. In the *Ostracodermi* (ὀστράκος, a box; δέρμα, skin) there is no spinous dorsal, the teeth are slender, and the body is inclosed in an immovable, bony box. In the *Gymnodontes* (γυμνός, naked; ὀδούς, tooth) the teeth are fused into a beak like that of a turtle, either continuous or divided by a median suture in each jaw, the spinous dorsal is lost, and the body is covered with thorns or prickles or else is naked.

The Sclerodermi.—The *Sclerodermi* include three recent and one extinct families. Of the recent forms, *Triacanthidæ* is the most primitive, having the ventral fins each represented by a stout spine and the skin covered with small, rough scales. The dorsal has from four to six stiff spines.

Triacanthodes anomalus is found in Japan, *Hollardia hollardi* in Cuba. *Triacanthus brevirostris*, with the first spine very large, is the common hornfish of the East Indies ranging northward to Japan.

The Trigger-fishes: Balistidæ.—The *Balistidæ*, or trigger-fishes, have the body covered with large rough scales regularly arranged.

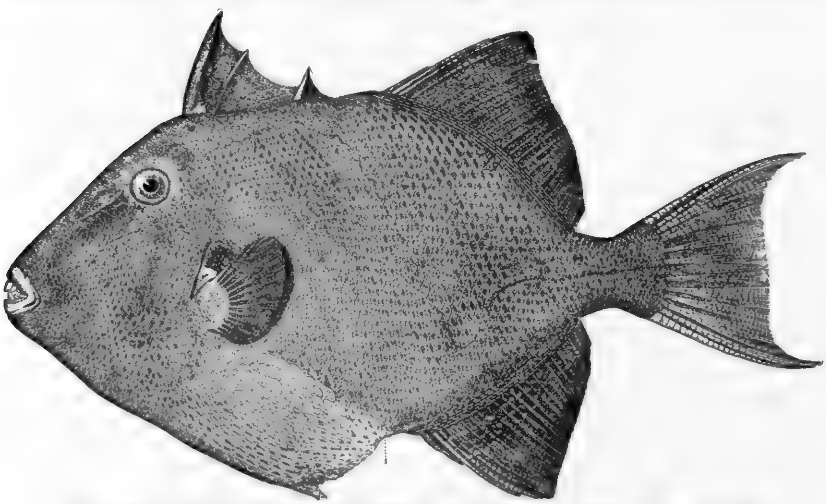


FIG. 345.—The Trigger-fish, *Balistes carolinensis* Gmelin. New York.

The first dorsal fin is composed of a short stout rough spine, with a smaller one behind it and usually a third so placed that by touching it the first spine may be set or released. This

peculiarity gives the name of trigger-fish as well as the older name of *Balistes*, or cross-bow shooter. There are no ventral fins, the long pelvis ending in a single blunt spine. The numerous species of trigger-fishes are large coarse fishes of the tropical seas occasionally ranging northward. The center of distribution is in the East Indies, where many of the species are most fantastically marked. *Balistes carolinensis*, the leather-jacket, or cucuyo, is found in the Mediterranean as also on the American coast. *Balistes vetula*, the oldwife, oldwench, or cochino, marked with blue, is common in the West Indies, as are several other species, as *Canthidermis sufflamen*, the sobaco, and the jet-black *Melichthys piceus*, the black oldwife, or galafata. Several species occur on the Pacific Coast of Mexico, the Pez Puerco, *Balistes verres*, being commonest. Still others are abundant about the Hawaiian Islands and Japan. The genus *Balistapus*, having spinous plates on the tail, contains the largest number of species, these being at the same time the smallest in size and the most oddly colored. *Balistapus aculeatus* and *Balistapus undulatus* are common through Polynesia to Japan. Most of the tropical species of *Balistidæ* are more or less poisonous, causing ciguatera, the offensive alkaloids becoming weaker in the northern species. *Melichthys radula* abounds in Polynesia. In this species great changes take place at death, the colors changing from blue and mottled golden green to jet black. Other abundant Polynesian species are *Xanthichthys lineopunctatus*, *Balistes vidua*, *Balistes bursa*, and *Balistes flavomarginatus*.

The File-fishes: Monacanthidæ.—Closely related to the *Balistidæ* are the *Monacanthidæ*, known as filefishes, or foolfishes. In these the body is very lean and meager, the scales being reduced to shagreen-like prickles. The ventral fins are replaced by a single movable or immovable spine, which is often absent, and the first dorsal fin is reduced to a single spine with sometimes a rudiment behind it. The species are in general smaller than the *Balistidæ* and usually but not always dull in color. They have no economic value and are rarely used as food, the dry flesh being bitter and offensive. The species are numerous in tropical and temperate seas, although none are found in Europe. On our Atlantic coast, *Stephano-*

lepis hispidus and *Ceratacanthus schœpfi* are common species. In the West Indies are numerous others, *Osbeckia lævis* and

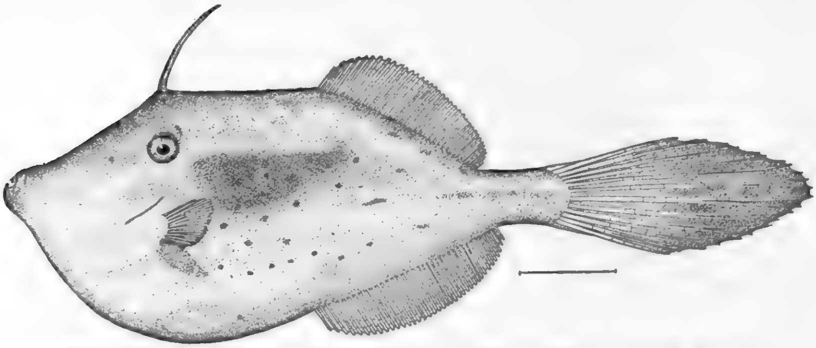


Fig. 346.—File-fish, *Osbeckia lævis* (*scripta*). Wood's Hole, Mass.

Alutera güntheriana, largest in size, among the commonest. Both of these are large fishes without ventral spine. *Monacanthus chinensis*, with a great, drooping dewlap of skin behind the

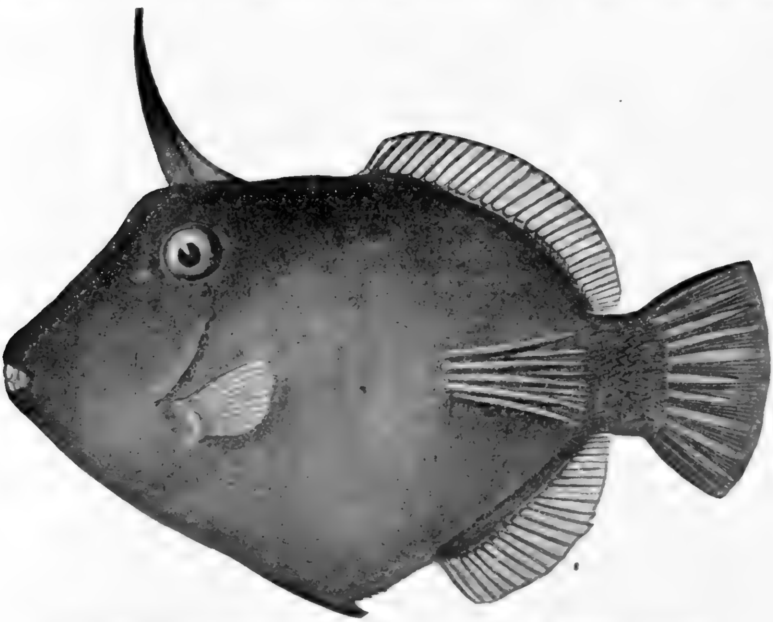


Fig. 347.—The Needle-bearing File-fish, *Amanses scopas* of Samoa.

ventral spine, is found on the coast of China. Of the numerous Japanese species, the most abundant and largest is *Pseudomon-*

acanthus modestus, with deep-blue fins and the ventral spine immovable. Another is *Stephanolepis cirrhifer*, known as *Kawamuki*, or skin-peeler. *Alutera monoceros*, and *Osbeckia scripta*, the unicorn fish, abound in the East Indies, with numerous others of less size and note. In the male of the Polynesian *Amanses scopas* (Fig. 347) the tail is armed with a brush of extraordinarily long needle-like spines.

In *Stephanolepis spilosomus* the caudal fin is of a brilliant scarlet color, contrasting with the usual dull colors of these fishes. In *Oxymonacanthus longirostris* the body is blue with orange checker-like spots and the snout is produced in a long tube. About the islands of Polynesia, filefishes are relatively few, but some of them are very curious in form or color.

The Spinacanthidæ.—In the extinct family *Spinacanthidæ* the body is elongate, high in front and tapering behind. The

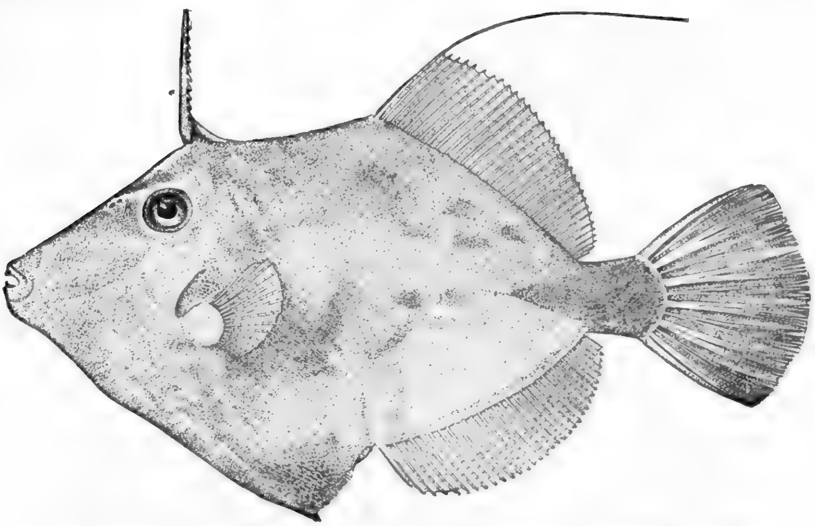


FIG. 348.—Common File fish, *Stephanolepis hispidus* (Linnæus). Virginia.

first dorsal has six or seven spines, and there are rough spines in the pectoral. The teeth are bluntly conical. *Spinacanthus blennioides* and *S. imperalis* are found in the Eocene of Monte Bolca. These are probably the nearest to the original ancestor among known scleroderms.

The Trunkfishes: Ostraciidæ.—The group *Ostracodermi* contains the single family of *Ostraciidæ*, the trunkfishes or cuck-

olds. In this group, the body is enveloped in a bony box, made of six-sided scutes connected by sutures, leaving only

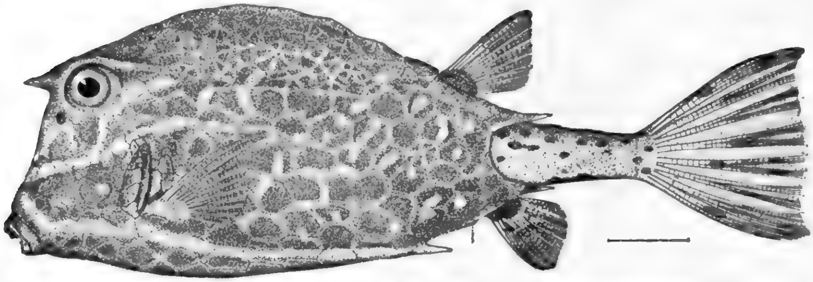


Fig. 349.—Horned Trunkfish, Cowfish, or Cuckold, *Lactophrys tricornis* (Linnæus). Charleston, S. C.

the jaws, fins and tail free. The spinous dorsal fin is wholly wanting. There are no ventral fins, and the outer fins are

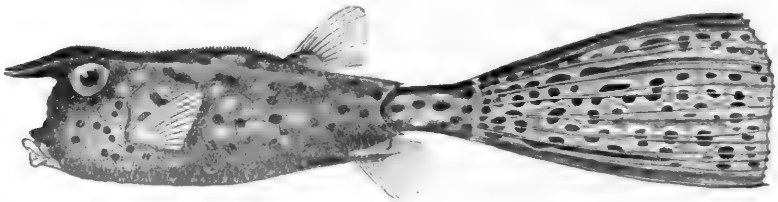


Fig. 350.—Horned Trunkfish, *Ostracion cornutum* (Linnæus). East Indies. (After Bleeker.)

short and small. The trunkfishes live in shallow water in the tropical seas. They are slow of motion, though often brightly colored.

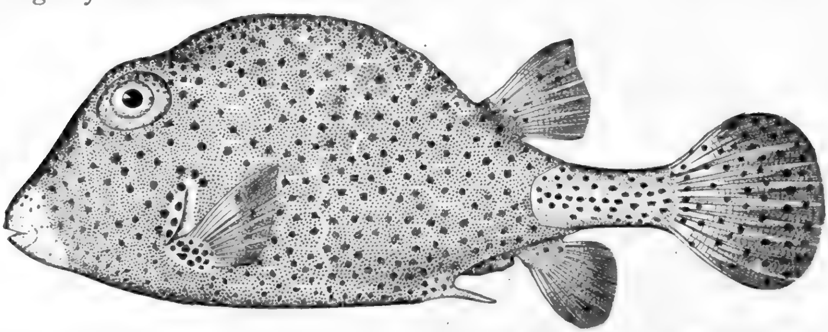


Fig. 351.—Spotted Trunkfish, *Lactophrys bicaudalis* (Linnæus). Cozumel Island, Yucatan.

Against most of their enemies they are protected by the bony case. The species range from four inches to a foot in

length, so far as known. They are not poisonous, and are often baked in the shell. Three genera are recognized: *Lactophrys* with the *carapace*, three-angled; *Ostracion* with four angles, and *Aracana*, resembling *Ostracion*, but with the carapace not closed behind the anal fin. In each of these genera there is considerable minor variation due to the presence or absence of spines on the bony shell. In some species, called cuckolds, or cowfishes, long horns are developed over the eye. Others have spines on some other part of the shield and some have no spines at all. No species are found in Europe, and none on the Pacific coast of America. The three-angled species, called *Lactophrys*, are native chiefly to the West Indies, sometimes carried by currents to Guinea, and one is described from Australia. *Lactophrys tricornis* of the West Indies has long

Fig. 352.—Spotted Trunkfish (face view), *Lactophrys bicaudalis* (Linnæus).

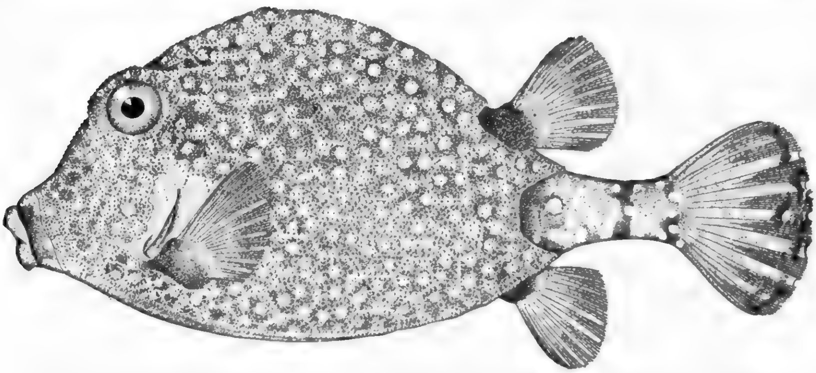


Fig. 353.—Spineless Trunkfish, *Lactophrys triqueter* (Linnæus). Tortugas.

horns over the eye; *Lactophrys trigonus* has spines on the lower parts only. *Lactophrys triqueter* is without spines, and the fourth American species, *Lactophrys bicaudalis*, is marked by large black spots. The species of *Ostracion* radiate from the East Indies. One of them, *Ostracion gibbosum*, has a turret-like spine on the middle of the back, causing the carapace to appear five-angled; *Ostracion diaphanum* has short horns over the eye, and *Ostracion cornutum* very long ones; *Ostracion*

immaculatus, the common species of Japan, is without spines; *Ostracion sebæ* of Hawaii and Samoa is deep, rich blue with spots of golden. *Aracana* is also of East Indian origin; *Aracana aculeata*, with numerous species, is common in Japan.

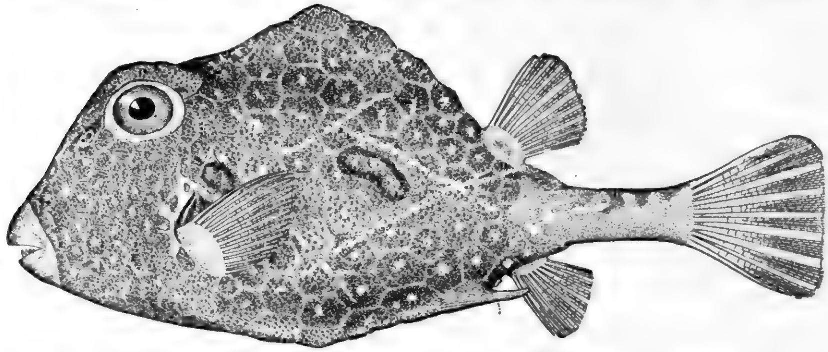


FIG. 354.—Hornless Trunkfish, *Lactophrys trigonus* (Linnæus). Tortugas, Fla.

A fossil species of *Ostracion* (*O. micrurum*) is known from the Eocene of Monte Bolca.

The Gymnodontes.—The group of *Gymnodontes*, having the teeth united in a turtle-like beak, carry still further the degeneration of scales and fins. There is no trace of spinous dorsal, or ventral. The scales are reduced to thorns or prickles, or are lost altogether. All the species have the habit of inflating themselves with air when disturbed, thus floating, belly upward, on the surface of the water. Very few, and these only northern species, are used as food, the flesh of the tropical forms being generally poisonous, and that often in a higher degree than any other fishes whatever.

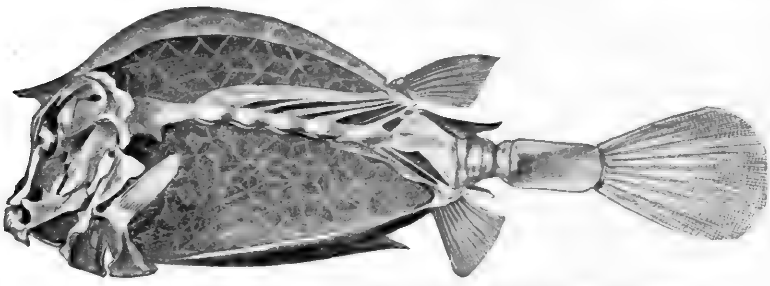


FIG. 355.—Skeleton of the Cowfish, *Lactophrys tricornis* (Linnæus).

The Triodontidæ.—The most generalized family is that of the *Triodontidæ*. These fishes approach the *Balistidæ* in several

regards, having the body compressed and covered with rough scales The teeth form a single plate in the lower jaw, but are divided on the median line above. The compressed, fan-like, ventral flap is greatly distensible. *Triodon bursarius*, of the East Indies and northward to Japan, is the sole species of the family.

The Globefishes: Tetraodontidæ.—In the *Tetraodontidæ* (globe-fishes, or puffers), each jaw is divided by a median suture. The dorsal and anal are short, and the ventrals are reduced

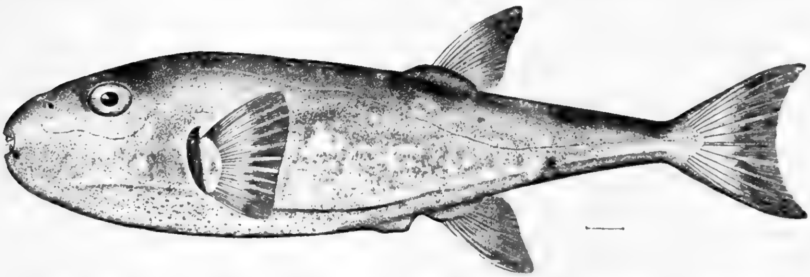


FIG. 356.—Silvery Puffer, *Lagocephalus lævigatus* (Linnæus). Virginia.

in number, usually fifteen to twenty (7+13 to 7+9). The walls of the belly are capable of extraordinary distension, so that when inflated, the fish appears like a globe with a beak and a short tail attached. The principal genus *Spheroides* contains a great variety of forms, forming a closely intergrading series. In some of these the body is smooth, in others more or less covered with prickles, usually three-rooted. In some the form is elongate, the color silvery, and the side of the belly with a conspicuous fold of skin. In these species, the caudal is lunate and the other fins falcate, and with numerous rays. But these forms (called *Lagocephalus*) pass by degrees into the short-bodied forms with small rounded fins, and no clear line has yet been drawn of the generic of this group. In these species each nostril has a double opening. *Lagocephalus lagocephalus*, large and silvery, is found in Europe. *Lagocephalus lævigatus* replaces it on the Atlantic Coast of North America. In Japan are numerous forms of this type, the venomous *Lagocephalus sceleratus* being one of the best known. Numerous other Japanese species, *Spheroides xanthopterus*, *rubripes*, *pardalis*, *ocellatus*, *vermiculatus*, *chrysops*, etc., mark the

transition to typical *Spheroides*. *Spheroides maculatus* is common on our Atlantic coast, the puffer, or swell-toad of the

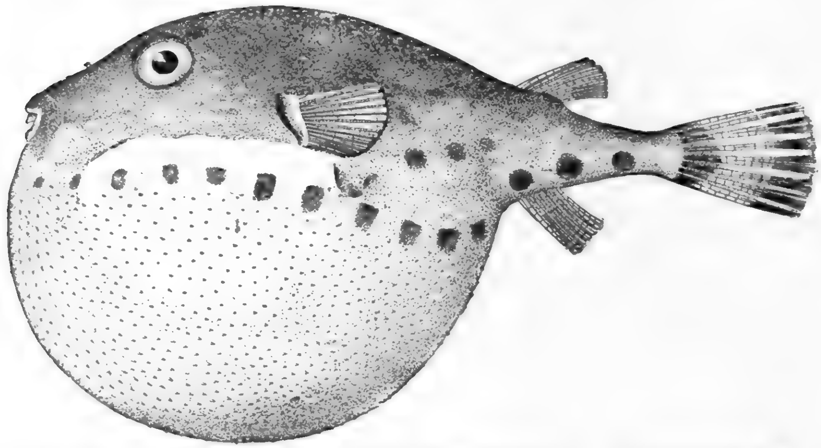


Fig. 357.—Puffer, inflated, *Spheroides spengleri* (Bloch). Wood's Hole, Mass.

coastwise boys who tease it to cause it to swell. *Spheroides spengleri* and *S. testudineus* abound in the West Indies. *Spheroides politus* on the west coast of Mexico.

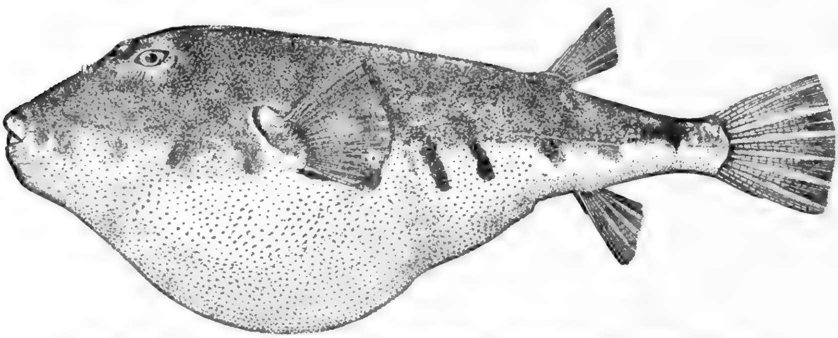


Fig. 358.—Puffer, *Spheroides maculatus* (Schneider). Noank, Conn.

In *Tetraodon* the nasal tentacle is without distinct opening, its tip being merely spongy. The species of this genus are even more inflatable and are often strikingly colored, the young sometimes having the belly marked by concentric stripes of black which disappear with age. *Tetraodon hispidus* abounds in estuaries and shallow bays from Hawaii to India. In Hawaii, it is regarded as the most poisonous of all fishes (muki-muki) and it is said that its gall was once used to

poison arrows. *Tetraodon fahaka* is a related species, the first known of the family. It is found in the Nile. *Tetraodon lacrymatus*, black with white spots, is common in Polynesia. *Tetraodon aërostaticus*, with black spots, is frequently taken in Japan, and *Tetraodon setosus* is frequent on the west coast of Mexico. This species is subject to peculiar changes of color. Normally dark brown, with paler spots, it is sometimes deep blue, sometimes lemon-yellow and sometimes of mixed shades.

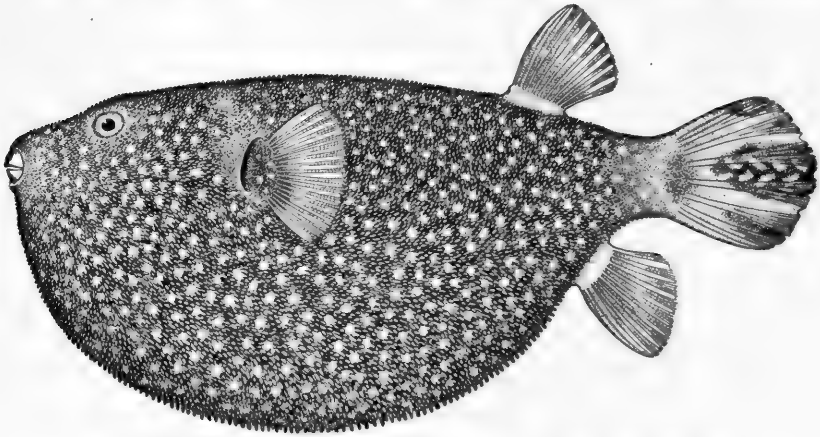


Fig. 359.—*Tetraodon meleagris* (Lacépède). Riu Kiu Islands.

Specimens showing these traits were obtained about Clarion Island of the Revillagigedos. No *Tetraodon* occurs in the West Indies. *Colomesus psittacus*, a river fish of the northern part of South America, resembles *Spheroides*, but shows considerable difference in the skull.

But few fossil *Tetraodontidæ* have been recognized. These are referred to *Tetraodon*. The earliest is *Tetraodon pygmæus* from Monte Bolca.

The *Chonerhinidæ* of the East Indies are globefishes having the dorsal and anal fins very long, the vertebræ more numerous (12 + 17), twenty-nine in number. *Chonerhinus naritus* inhabits the rivers of Sumatra and Java.

The little family of *Tropidichthyidæ* is composed of small globefishes, with a sharply-keeled back, and the nostrils almost, or quite, wanting. The teeth are as in the *Tetraodontidæ*. The skeleton differs considerably from that of *Spheroides*, apparently justifying their separation as a family. The species

are all very small, three to six inches in length, and prettily colored. In the West Indies *Tropidichthys rostratus* is found. *Tropidichthys solandri* abounds in the South Seas, dull orange with blue spots. *Tropidichthys rivulatus* is common in Japan and several other species are found in Hawaii.

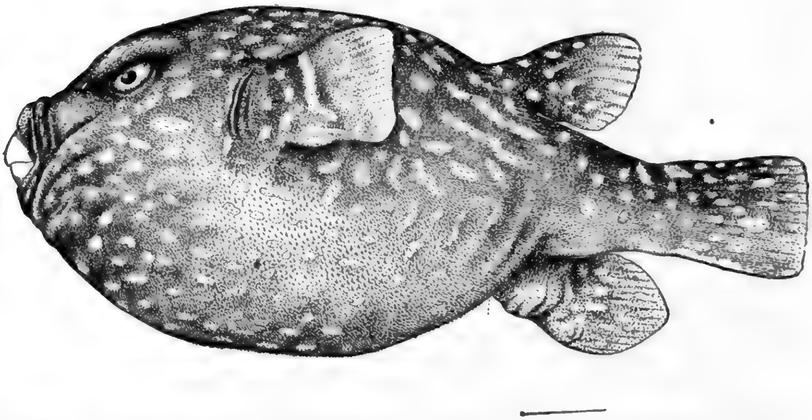


Fig. 360.—Bristly Globefish, *Tetraodon setosus* Rosa Smith. Clarion Island, Mex.

Other species occur on the west coast of Mexico, in Polynesia, and in the East Indies.

The Porcupine-fishes: Diodontidæ. — In the remaining families of *Gymnodontes*, there is no suture in either jaw, the teeth

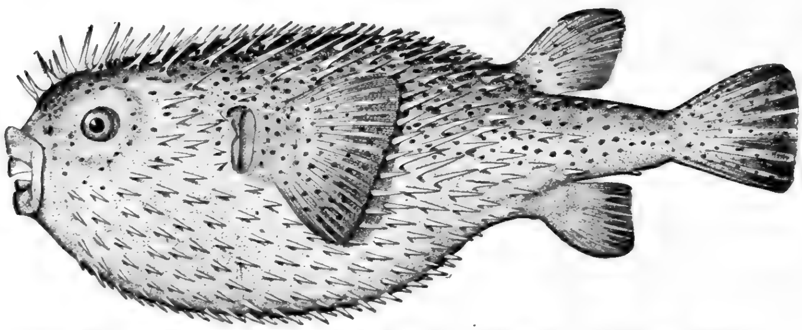


Fig. 361.—Porcupine-fish, *Diodon hystrix* (Linnæus). Tortugas Islands.

forming an undivided beak. The *Diodontidæ*, or porcupine-fishes, have the body spherical or squarish, and armed with sharp thorns, the bases of which are so broad as to form a continuous coat of mail. In some of them, part of the spines are movable, these being usually two-rooted; in others, all are immovable

and three-rooted. All are reputed poisonous, especially in the equatorial seas.

In *Diodon* the spines are very long, the anterior ones, at least, movable. The common porcupine-fish, *Diodon hystrix*, is found in all seas, and often in abundance. It is a sluggish fish, olive and spotted with black. It reaches a length of two feet or more, and by its long spines it is thoroughly protected from all enemies. A second species, equally common, is the lesser porcupine-fish, *Diodon holacanthus*. In this species, the frontal spines are longer than those behind the pectoral, instead of the reverse, as in *Diodon hystrix*. Many species of *Diodon* are recorded from the Eocene, besides numerous species from later deposits. One of these, as *Heptadiodon heptadiodon* from the Eocene of Italy, with the teeth subdivided, possibly represents a distinct family. *Diodon erinaceus* is found in the Eocene of Monte Bolca and *Progymnodon hilgendorfi* in the Eocene of Egypt.

In the rabbit-fishes (*Chilomycterus*) the body is box-shaped,

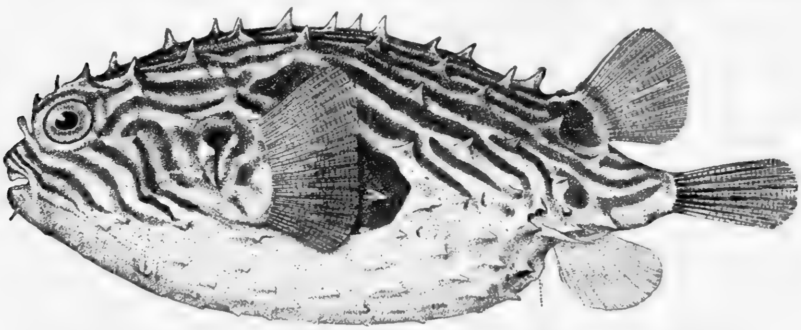


Fig. 362.—Rabbit-fish, *Chilomycterus schœpfi* (Walbaum). Noank, Conn.

covered with triangular spines, much shorter and broader at base than those of *Diodon*. Numerous species are known.

Chilomycterus schœpfi is the common rabbit-fish, or swell-toad of our Atlantic coast, light green, prettily varied with black lines. The larger, *Chilomycterus affinis*, with the pectoral fin spotted with black, is widely diffused through the Pacific. It is rather common in Japan, where it is the torabuku, or tiger puffer. It is found also in Hawaii, and it is once recorded by Dr. Eigenmann from San Pedro, California, and once by Snodgrass and Heller, from the Galapagos.

The Head-fishes: Molidæ.—The head-fishes, or *Molidæ*, also called sunfishes, have the body abbreviated behind so that the dorsal, anal, and caudal seem to be attached to the posterior outline of the head. This feature, constituting the so-called gephyrocercal tail is a trait of specialized degradation.

Mola mola, the common head-fish or sunfish, is found occasionally in all tropical and temperate seas. Its form is almost

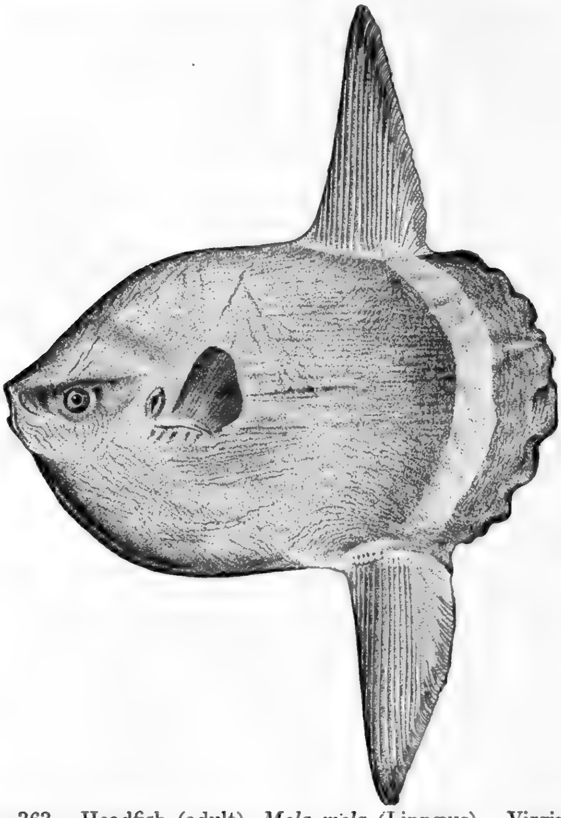


Fig. 363.—Headfish (adult), *Mola mola* (Linnæus). Virginia.

circular, having been compared by Linnæus to a mill-wheel (mola), and its surface is covered with a rough, leathery skin. It swims very lazily at the surface of the water, its high dorsal often rising above the surface. It is rarely used as food, though not known to be poisonous. The largest example known to the writer was taken at Redondo Beach, California, by Mr. Thomas Shooter, of Los Angeles. This specimen was 8 feet 2 inches in

length, and weighed 1200 pounds. Another, almost as large, was taken at San Diego, in April, 1904. No difference has been noticed among specimens from California, Cape Cod, Japan, and the Mediterranean. The young, however, differ considerably from the adult, as might be expected in a fish of such great size and extraordinary form. (See Figs. 109 and 110, Vol. I.)

Fragments named *Chelonopsis*, and doubtfully referred to *Mola*, are found in the Pliocene of Belgium. Certain jaws of cretaceous age, attributed to *Mola*, probably belong, according to Woodward, to a turtle

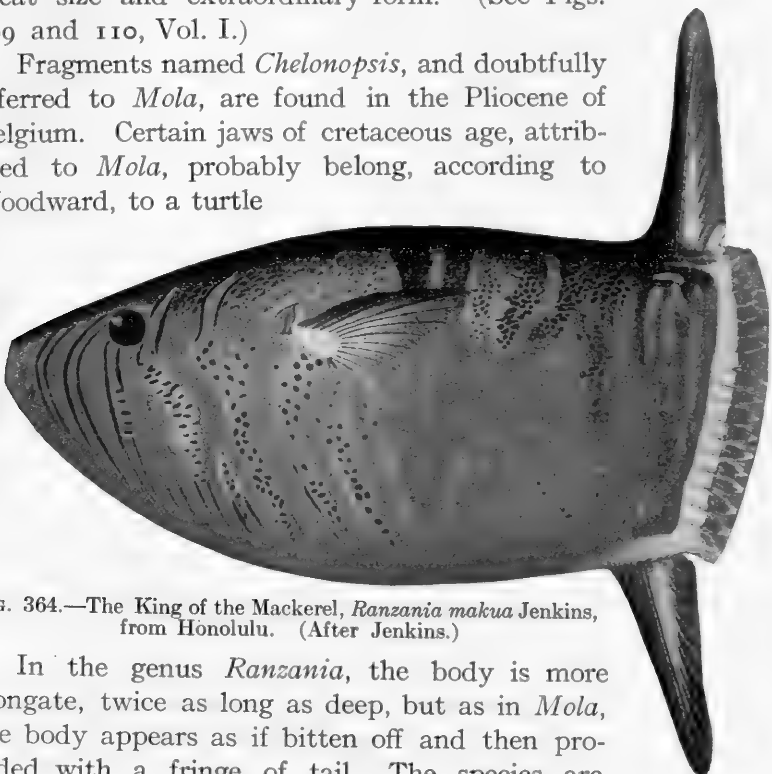


FIG. 364.—The King of the Mackerel, *Ranzania makua* Jenkins, from Honolulu. (After Jenkins.)

In the genus *Ranzania*, the body is more elongate, twice as long as deep, but as in *Mola*, the body appears as if bitten off and then provided with a fringe of tail. The species are rarely taken. *Ranzania truncata* is found in the Mediterranean and once at Madeira. *Ranzania makua*, known as the king of the mackerels about Hawaii, is beautifully colored brown and silvery. This species has been taken once in Japan.

In Hawaii it is believed that all the Scombroid fishes are subject to the rule of the makua and that they will disappear if this fish be killed. By a similar superstition, *Regalecus glesne* is "king of the herrings" in Norway and about Cape Flattery, *Trachypterus rex salmonorum* is "king of the salmon."

CHAPTER XXV

PAREIOPLITÆ, OR MAILED-CHEEK FISHES

THE **Mailed-cheek Fishes.** — The vast group of *Pareioplitæ* (*Loricati*) or mailed-cheek fishes is characterized by the presence of a "bony stay" or backward-directed process from the third suborbital. This extends backward across the cheek toward the preopercle. In the most generalized forms this bony stay is small and hidden under the skin. In more specialized forms it grows larger, articulates with the preopercle, and becomes rough or spinous at its surface. Finally, it joins the other bones to form a coat of mail which covers the whole head. In degenerate forms it is again reduced in size, finally becoming insignificant.

The more primitive *Pareioplitæ* (*παρεία*, cheek; ὁπλιτής, armed) closely resemble the *Percomorphi*, having the same fins, the same type of shoulder-girdle, and the same insertion of the ventral fins. In the more specialized forms the ventral fins remain thoracic, but almost all other parts of the anatomy are greatly distorted. In all cases, so far as known to the writer, the hypercoracoid is perforate as in the *Percomorphi*. There are numerous points of resemblance between the *Cirrhitidæ* and the *Scorpænidæ*, and it is probable that the *Scorpænidæ* with all the other *Pareioplitæ* sprang from some perciform stock allied to *Cirrhitidæ* and *Latrididæ*.

Fossil mailed-cheek fishes are extremely few and throw little light on the origin of the group. Those belong chiefly to the *Cottidæ*. *Lepidocottus*, recorded from the Miocene and Oligocene, seems to be the earliest genus.

The Scorpion-fishes: Scorpænidæ. — The vast family of *Scorpænidæ*, or scorpion-fishes, comprises such a variety of forms as almost to defy diagnosis. The more primitive types are

percoid in almost all respects, save in the presence of the sub-ocular stay. Their scales are ctenoid and well developed. The dorsal spines are numerous and strong. The ventral fins are complete and normally attached; the anal has three strong

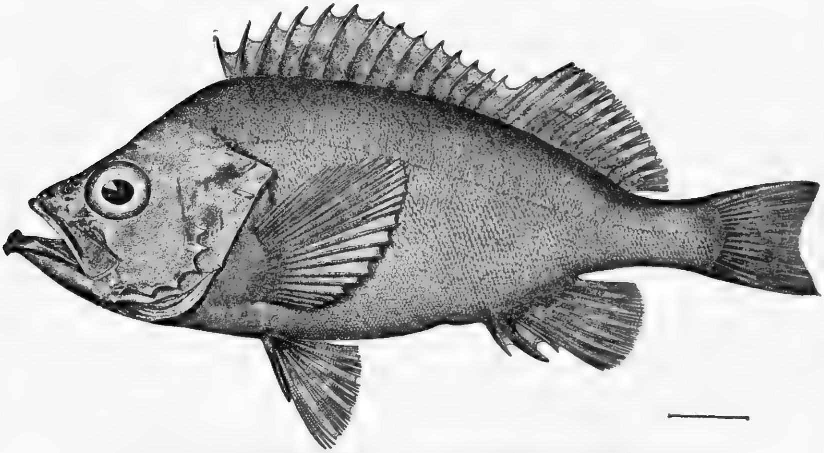


FIG. 365.—Rosefish, *Sebastes marinus* Linnæus. Cape Cod.

spines. The cranium shows only a trace of spiny ridges, and the five spines on the preoperculum are not very different from those seen in some species of bass. The gill-arches are, however, different, there being but $3\frac{1}{2}$ gills and no slit behind the last.

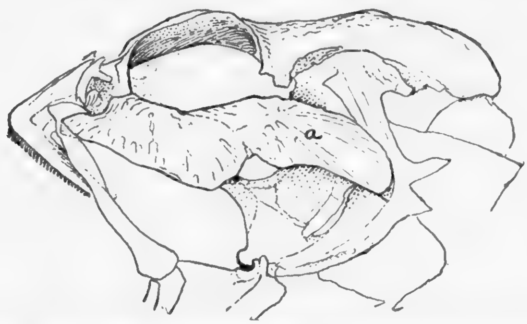


FIG. 366.—Skull of *Scorpænichthys marmoratus* Girard, showing the suborbital stay (*a*).

Otherwise the mouth and pharanx show no unusual characters. In the extremes of the group, however, great changes take place, the head becomes greatly distorted with ridges and grooves, the anal spines are lost, and the dorsal spines variously modified. The scales may be lost or replaced by warts or

prickles and the ventral fins may be greatly reduced. Still the changes are very gradual, and it is not easy to divide the group into smaller families.

The most primitive existing genus is doubtless *Sebastes*. The familiar rosefish, *Sebastes marinus*, is found on both shores of the north Atlantic. It is bright red in color and is valued as food. As befits a northern fish, it has an increased number of vertebræ (31) and the dorsal spines number 15. From its large haddock-like eye it has been called the Norway haddock. It is an important food-fish in New England as well as in northern Europe.

In the north Pacific *Sebastes* gives place to *Sebastolobus*, with three species (*macrochir*, *altivelis*, and *alascanus*), all bright-

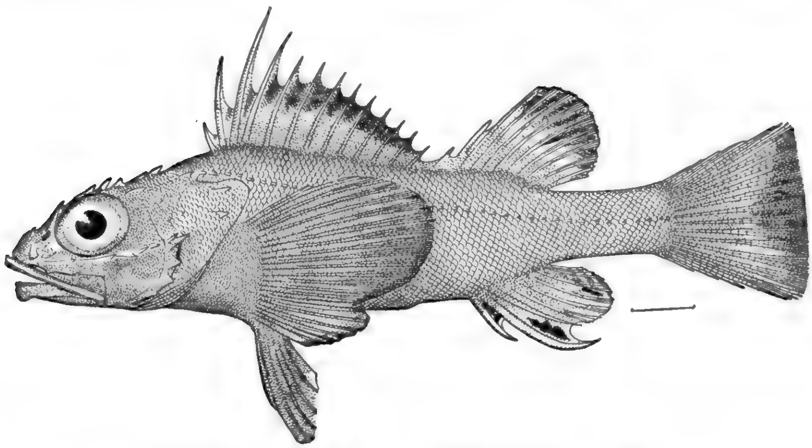


Fig. 367.—*Sebastolobus altivelis* Gilbert. Alaska.

red fishes of soft substance and living in rather deep water. *Sebastolobus* is characterized by its two-lobed pectoral fin, the lower rays being enlarged.

The genus *Sebastodes*, with its rougher-headed ally *Sebastichthys*, with 13 dorsal spines and the vertebræ 27, ranges farther south than *Sebastes* and forms one of the most characteristic features of the fauna of California and Japan, 50 species occurring about California and 25 being already known from Japan. One species (*Sebastichthys capensis*) is recorded from the Cape of Good Hope, and two, *Sebastichthys oculatus* and *S. darwini*, from the coast of Chile.

Within the limits of *Sebastodes* and *Sebastichthys* is a very large range of form and color, far more than should exist within the range of a natural genus. On the other hand, all attempts at generic subdivision have failed because the species form a number of almost perfectly continuous series. At one extreme are species with large mouths, small scales, relatively smooth cranium, and long gill-rakers. At the other extreme are robust species, with the head very rough, the mouth moderate, the scales larger, and the gill-rakers short and thick. Still other species have slender cranial spines and spots of bright pink in certain specialized localities. These approach the genus *Helicolenus* as other species approach *Scorpæna*.

The various species are known in California as rockfish, or rock-cod, in Japan as Soi and Mebaru. In both regions they form a large part of the bulk of food-fishes, the flesh being rather coarse and of moderate flavor. All the species so far as known are ovoviviparous, the young being brought forth in summer in very great number, born at the length of about ¼ of an inch. The species living close to shore are brown, black, or green. Those living in deeper waters are bright red, and in still deeper waters often creamy or gray, with the lining of the mouth and the peritoneum black. The largest species reach a length of two or three feet, the smallest eight or ten inches. None are found between Lower California and Peru and none south of Nagasaki in Japan. Of the California species the following are of most note: *Sebastodes paucispinis*, the Bocaccio of the fishermen, from its large mouth, is an elongate fish, dull red in color, and reaching a very large size. In deeper waters are *Sebastodes jordani* and *Sebastodes goodei*, the former elongate and red, the latter more robust and of a very bright crimson color. *Sebastodes ovalis*, the viuva, and *Sebastodes entomelas* are grayish in hue, and the related *Sebastodes proriger* is red. The green rockfish *Sebastodes flavidus* is common along the shore, as also the black rockfish, known as pêche prêtre or priestfish, *Sebastodes mystinus*. Less common is *Sebastodes melanops*. Similar to this but more orange in color is the large *Sebastodes miniatus*. Somewhat rougher-headed is the small grass rockfish, *Sebastodes atrovirens*. On the large red rockfish, *Sebastichthys ruberrimus*, the spinous

ridges are all large and rough serrate. On the equally large *Sebastichthys levis* these ridges are smooth. Both these species are bright red in color. *Sebastichthys rubrovinctus*, called the Spanish-flag, is covered with broad alternating bands of deep crimson and creamy pink. It is the most handsomely colored of our marine fishes and is often taken in southern California. *Sebastichthys elongatus* is a red species with very large mouth. Several other species small in size are red, with three or four spots of bright pink. The commonest of these is the corsair,

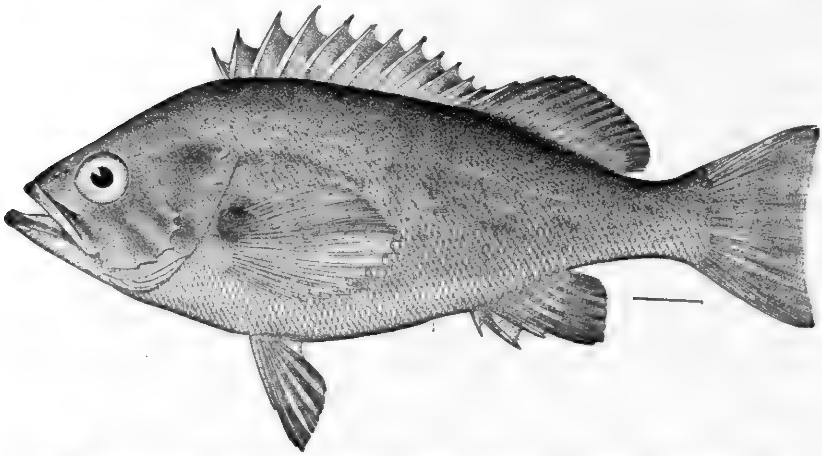


FIG. 368.—Priest-fish, *Sebastodes mystinus* Jordan & Gilbert. Monterey, Cal.

Sebastichthys rosaceus, plain red and golden. Another species is the green and red flyfish, *Sebastichthys rhodochloris*. *Sebastichthys constellatus* is spotted with pink and *Sebastichthys chlorostictus* with green. To this group with pink spots the South American and African species belong, but none of the Japanese. *Sebastodes aleutianus* is a large red species common in Alaska and *Sebastodes ciliatus* a green one. About the wharves in California and northward the brown species called *Sebastichthys auriculatus* is abundant. In the remaining species the spinous ridges are progressively higher, though not so sharp as in some of those already named. *Sebastichthys maliger* has very high dorsal spines and a golden blotch on the back. In *Sebastichthys caurinus* and especially *Sebastichthys vexillaris* the spines are very high, but the coloration is different, being reddish brown. *Sebastichthys nebulosus* is blue-black with golden

spots. *Sebastichthys chrysomelas* is mottled black and yellow. *Sebastichthys carnatus* is flesh-color and green. *Sebastichthys rastrelliger* is a small, blackish-green species looking like *Sebastodes atrovirens*, but with short gill-rakers. *Sebastichthys hopkinsi* and *Sebastichthys gilberti* are small species allied to it. The treefish, *Sebastichthys serriceps*, has very high spines on the head, and the olive body is crowned by broad black bands. Still more striking is the black-banded rockfish, *Sebastichthys*

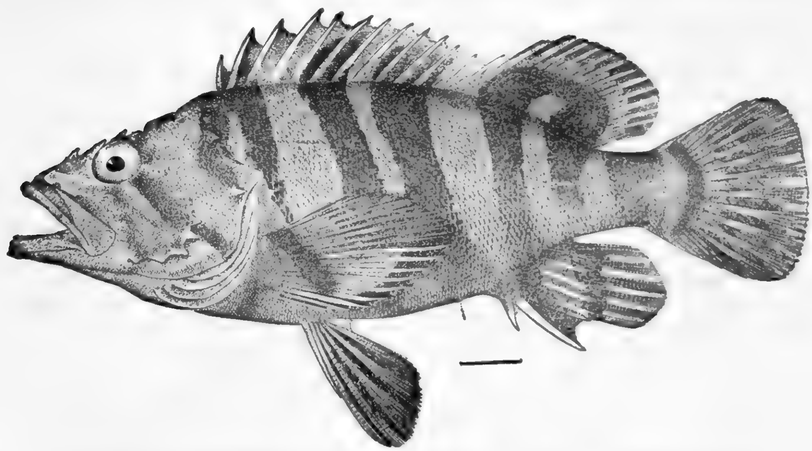


FIG. 369.—*Sebastichthys serriceps* Jordan & Gilbert. Monterey, Cal.

nigrofasciatus, with very rough head and bright red body with broad cross-bands of black.

Of the Japanese species the commonest, *Sebastodes inermis*, the Mebaru, much resembles *Sebastodes flavidus*. *Sebastodes fuscescens* looks like *Sebastodes melanops*, as does also *Sebastodes taczanowskii*. *Sebastodes matsubaræ* and *S. flammeus* and *S. iracundus*, bright-red off-shore species, run close to *Sebastodes aleutianus*. *Sebastichthys pachycephalus* suggests *Sebastichthys chrysomelas*. *Sebastodes steindachneri* and *S. itinus* are brighter-colored allies of *Sebastodes ovalis* and *Sebastodes scythropus* and *Sebastodes joyneri* represent *Sebastodes proriger*. *Sebastichthys trivittatus*, green, striped with bright golden, bears some resemblance to *Sebastichthys maliger*. *Sebastichthys elegans*, *Sebastichthys oblongus*, and *Sebastichthys mitsukurii*, dwarf species, profusely spotted, have no analogues among the American forms. *Sebastodes glaucus* of the Kurile Islands has 14 dorsal spines

and is not closely related to any other. Fourteen dorsal spines are occasionally present in *Sebastichthys elegans*. All the other species show constantly 13.

The genus *Sebastiscus* has the general appearance of *Sebastodes*, and like the latter possesses a large air-bladder. It however agrees with *Scorpæna* in the possession of but 12 dorsal spines and 24 vertebræ. The two known species are common in Japan. *Sebastiscus marmoratus*, mottled brown, is everywhere

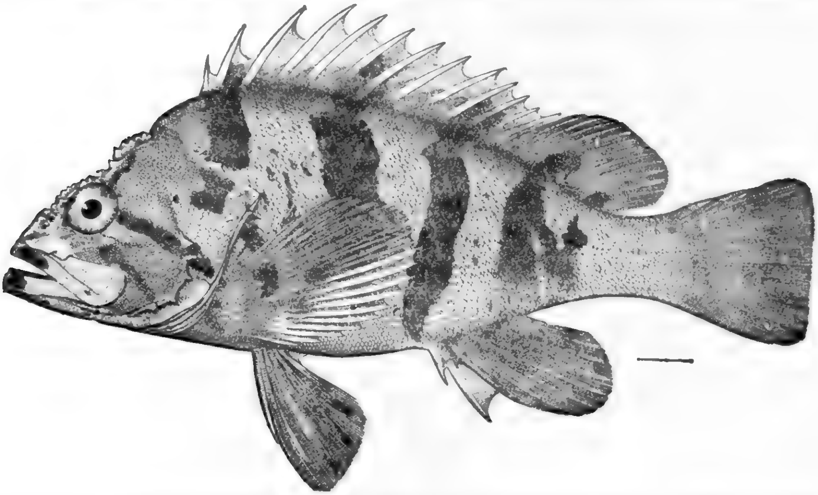


FIG. 370.—Banded Rockfish, *Sebastichthys nigrocinctus* (Ayres). Straits of Fuca.

abundant along the coast, and the pretty *Sebastiscus albofasciatus*, pink, violet, and golden, represents it in equal abundance in deeper water.

The genus *Sebastopsis* differs from *Sebastodes* only in having no teeth on the palatines. The species, all of small size and red or varied coloration, are confined to the Pacific. *Sebastopsis xyris* occurs in lower California and *Sebastopsis guamensis* and *S. scaber* in Polynesia. Species of this genus are often found dried in Chinese insect boxes.

Helicolenus differs from *Sebastiscus* only in the total absence of air-bladder. The species are all bright crimson in color, very handsome, and live in deep water. *Helicolenus dactylopterus* is rather common in the Mediterranean, and is sometimes taken in the Gulf Stream, and also in Japan, where two or three other species occur.

Neosebastes is much like *Sebastodes*, but the suborbital stay bears strong spines and the dorsal is very high. *Neosebastes panda* is found in Australia, and *N. entaxis* in Japan. *Setarches* is distinguished by the cavernous bones of its head. Species are found in both the Atlantic and Pacific in deep water. Several other peculiar or transitional genera are found in different parts of the Pacific.

In *Scorpæna* the head is more uneven in outline than in *Sebastodes* and *Sebastichthys*, skinny flaps are often present on head and body, the air-bladder is wanting, there are 12 dorsal

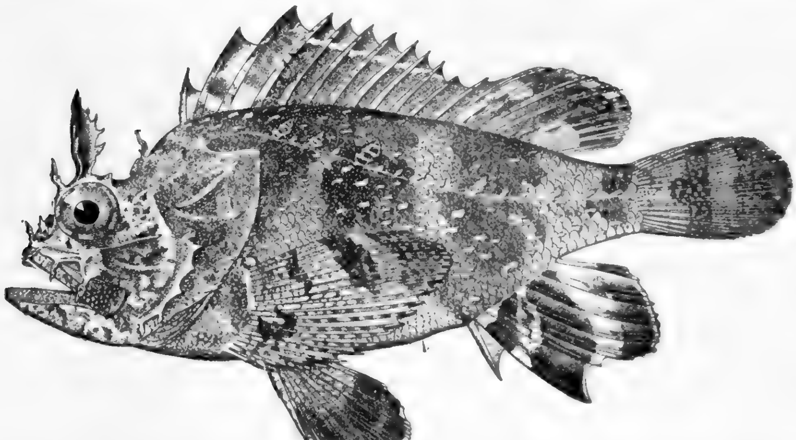


FIG. 371.—Florida Lion fish, *Scorpæna grandicornis* Cuv. & Val. Key West.

spines and 24 vertebræ, and on each dorsal spine is a small venom-secreting gland. The species are very numerous, highly varied in color, and found in all warm seas, being known as scorpion-fishes or *Rascacios*. Two species, *Scorpæna scrofa* and *Scorpæna porcus*, are common in the Mediterranean, being regarded as good food-fishes, though disliked by the fishermen.

Of the numerous West Indian species, *Scorpæna plumieri*, *Scorpæna grandicornis*, and *Scorpæna brasiliensis* are best known. *Scorpæna guttata* is common in southern California and is an excellent food-fish. *Scorpæna mystes* is found on the west coast of Mexico. *Scorpæna onaria* and *S. izensis* are found in Japan. Fossil remains referred to *Scorpæna* are recorded from the Tertiary rocks.

In the islands of the Pacific are numerous dwarf species less than three inches long, which have been set apart as a separate genus, *Sebastapistes*. The longest known of these is *Sebastapistes strongensis*, named from Strong Island, abundant in crevices in the corals throughout Polynesia, and much disliked by fishermen.

The genus *Scorpænopsis* differs from *Scorpæna* in the absence of palatine teeth. It is still more fantastic in form and color.

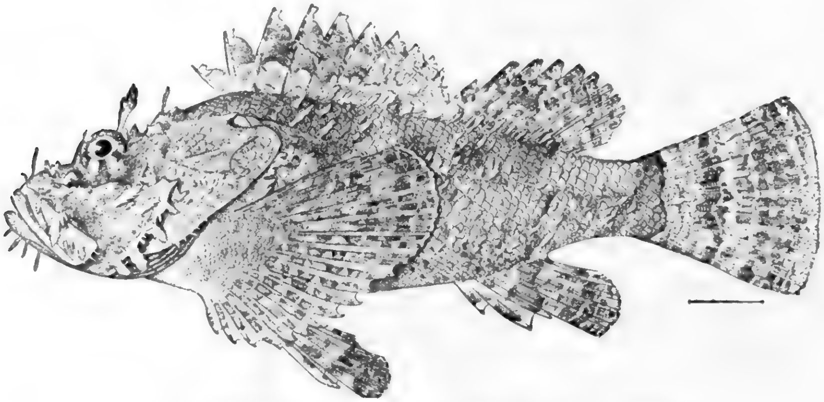


FIG. 372.—Sea-scorpion, *Scorpæna mystes* Jordan. Mazatlan.

Scorpænopsis cirrhosa, *Scorpænopsis fimbriata*, and other species are widely distributed through the East Indies and Polynesia.

The lion-fishes (*Pterois*) of the tropical Pacific are remarkable for their long pectoral fins, elongate dorsal spines, and zebra-like coloration. The numerous species are fantastic and handsomely colored, but their poisoned, needle-like spines are dreaded by fishermen. They lurk in crevices in the coral reefs, some of them reaching a foot in length.

Inimicus japonicus, common in Japan, has a depressed and monstrous head and a generally bizarre appearance. It is usually black in color but is largely bright red when found among red algæ. A related species, *Inimicus aurantiacus*, is blackish when near shore, but lemon-yellow in deep water. (See frontispiece.) A related species in the East Indies is *Pelor filamentosum*, called *Nohu* or *Gofu* in Polynesia.

Still more monstrous are the species of *Synanceia*, short, thick-set, irregularly formed fishes, in which the poisoned spines

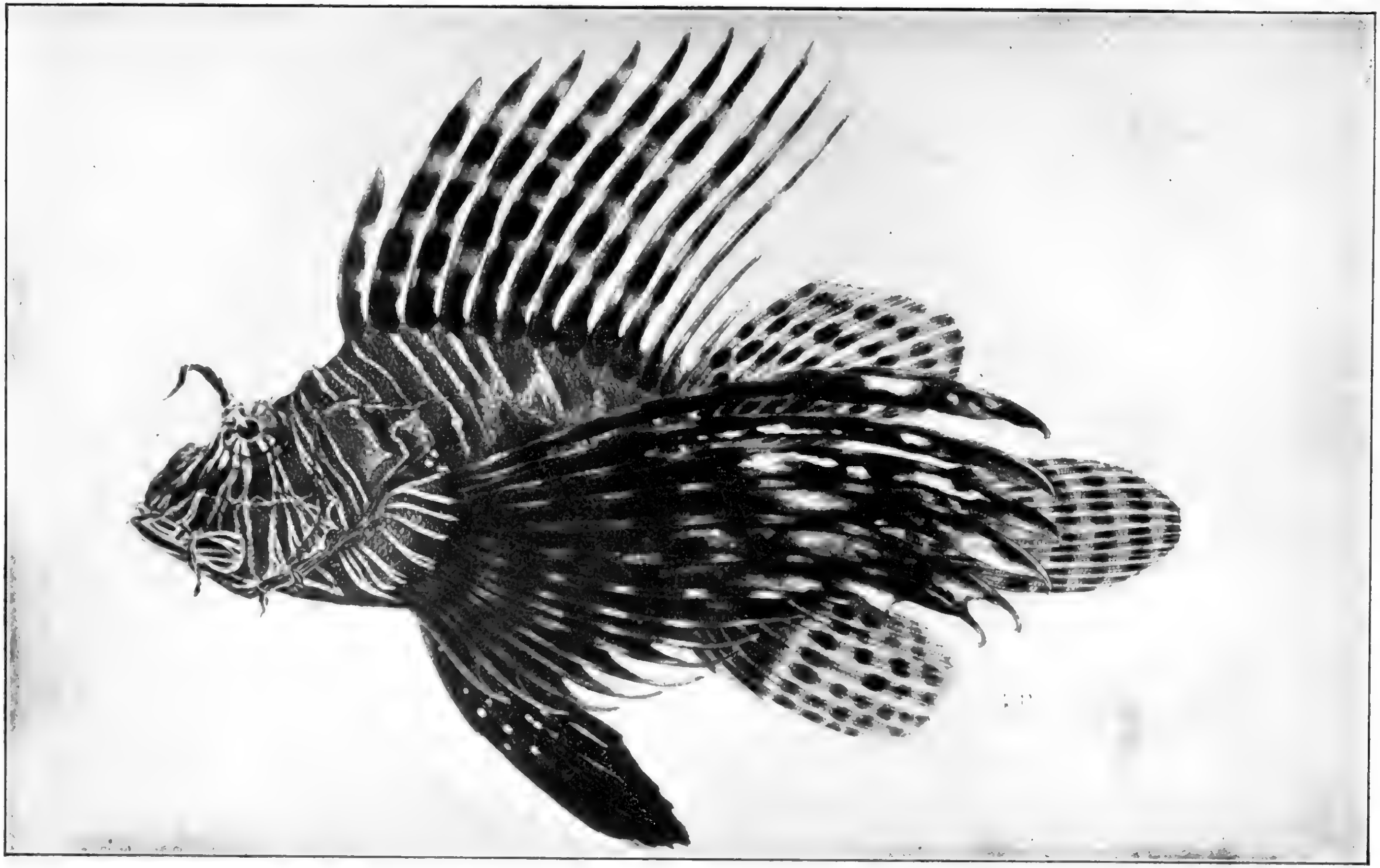


Fig. 373.—Lion-fish or Sausolele (the dorsal spines envenomed), *Pterois volitans* (Linnæus). Family *Scorpænidæ*. (From a specimen from Samoa.)

reach a high degree of venom. The flesh in all these species is wholesome, and when the dorsal spines are cut off the fishes sell readily in the markets. These fishes lie hidden in cavities of the reefs, being scarcely distinguishable from the rock itself. (See Fig. 168, Vol. I.)

The black *Emmydrichthys vulcanus* of Tahiti lies in crevices of lava, and could scarcely be distinguished from an irregular lump of lava-rock.

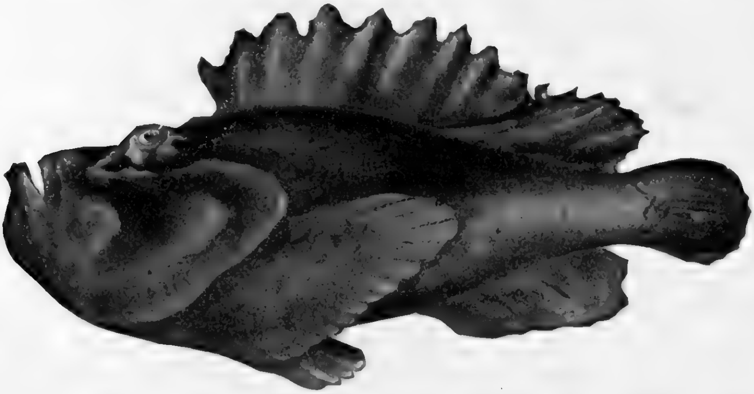


FIG. 374.—Black Nohu, or Poison-fish, *Emmydrichthys vulcanus* Jordan. A species with stinging spines, showing resemblance to lumps of lava among which it lives. Family *Scorpænidæ*. From Tahiti.

A related form, *Erosa erosa*, the daruma-okose of Japan, is monstrous in form but often beautifully colored with crimson and gray.

In *Congiopus* the very strong dorsal spines begin in the head, and the mouth is very small. Dr. Gill makes this genus the type of a distinct family, *Congiopodidæ*.

Besides these, very many genera and species of small poison-fishes, called okose in Japan, abound in the sandy bays from Tokio to Hindostan and the Red Sea. Some of these are handsomely colored, others are fantastically formed. *Paracentropogon rubripinnis* and *Minous adamsi* are the commonest species in Japan. *Trachicephalus uranoscopus* abounds in the bays of hina. *Snyderina yamanokami* occurs in Southern Japan.

But few fossil *Scorpænidæ* are recorded. *Scorpænopterus siluridens*, a mailed fish from the Vienna Miocene, with a warty head, seems to belong to this group, and *Ampheristus toliapicus*,

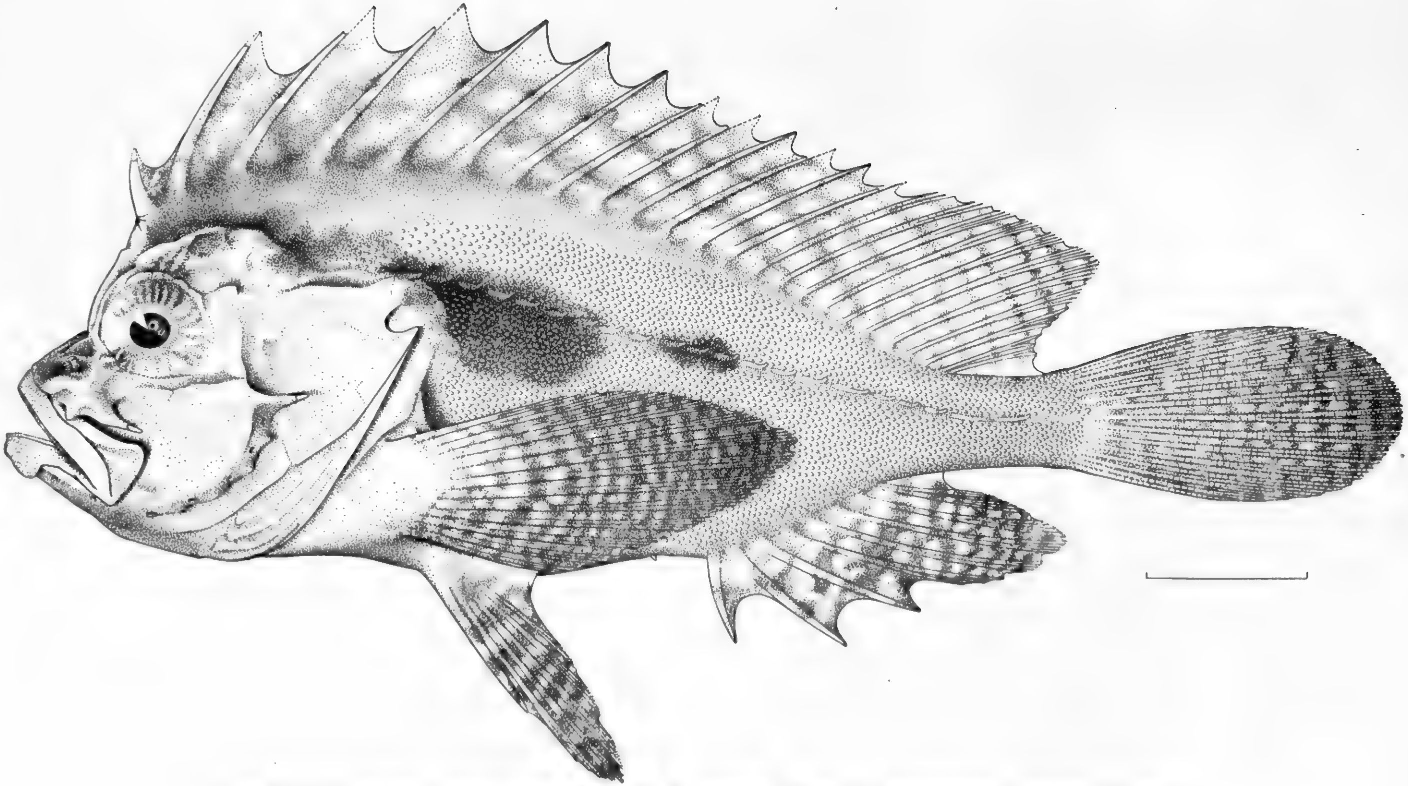


FIG. 375.—*Snyderina yamanokami* Jordan & Starks. Family *Scorpænidæ*. Satsuma, Japan.

with a broad, depressed head, is found in the London Eocene, and various Miocene species have been referred to *Scorpæna*. *Sebastodes rosæ* is based on a fragment, probably Pleistocene, from Port Harford, California.

The small family of the *Caracanthidæ* consists of little fishes

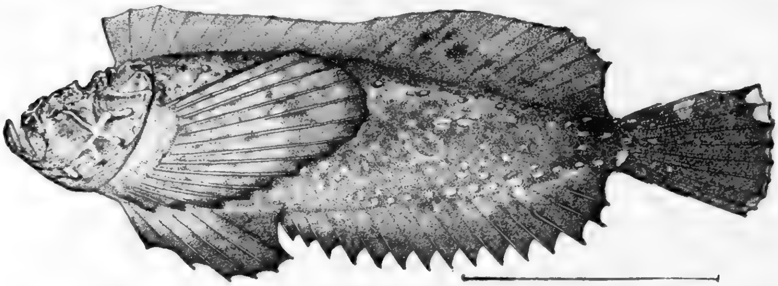


FIG. 376.—*Trachicephalus uranoscopus*. Family *Scorpænidæ*. From Swatow, China.

of the coral reefs of the Pacific. These are compressed in form, and the skin is rough with small prickles, the head being feebly armed. The species are rare and little known, brown in color with pale spots.

The Skilfishes: Anoplopomidæ.—The small family of skilfishes or *Anoplopomidæ* consists of two species found on the

FIG. 377.—Skilfish, *Anoplopoma fimbria* (Pallas). California.

coast of California and northward. These resemble the *Scorpænidæ*, having the usual form of nostrils, and the suborbital stay well developed. The skull is, however, free from spines, the scales are small and close-set, and the sleek, dark-colored body has suggested resemblance to the mackerel or hake. *Anoplopoma fimbria*, known as skilfish, beshow, or coal-fish, is rather common from Unalaska to Monterey, reaching a length of two feet or more. In the north it becomes very

fat and is much valued as food. About San Francisco it is dry and tasteless.

The Greenlings: Hexagrammidæ.—The curious family of greenlings, *Hexagrammidæ*, is confined to the two shores of the North Pacific. The species vary much in form, but agree in the unarmed cranium and in the presence of but a single nostril on each side, the posterior opening being reduced to a minute pore. The vertebræ are numerous, the scales small, and the coloration often brilliant. The species are carnivorous and usually valued as food. They live in the kelp and about rocks in California and Japan and along the shores of Siberia and

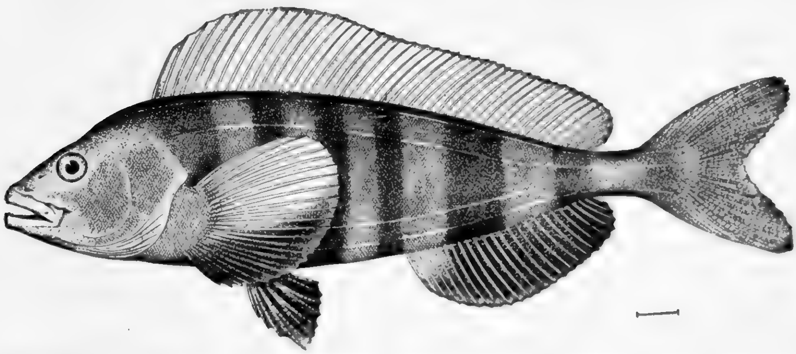


FIG. 378.—Atka-fish, *Pleurogrammus monopterygius* (Pallas). Atka Island.

Alaska. The atka-fish (*Pleurogrammus monopterygius*) is one of the finest of food-fishes. This species reaches a length of eighteen inches. It is yellow in color, banded with black, and the flesh is white and tender, somewhat like that of the Lake whitefish (*Coregonus clupeiformis*), and is especially fine when salted. This fish is found about the Aleutian Islands, especially the island of Atka, from which it takes its name. It is commercially known as Atka mackerel.

In this genus there are numerous lateral lines, and the dorsal fin is continuous. In *Hexagrammos*, the principal genus of the family, the dorsal is divided into two fins, and there are about five lateral lines on each side.

Hexagrammos decagrammus is common on the coast of California, where it is known by the incorrect name of rock-trout. It is a well-known food-fish, reaching a length of eighteen inches.

The sexes are quite unlike in color, the males anteriorly with blue spots, the females speckled with red or brown.

Hexagrammos octogrammus, the common greenfish of Alaska, and the greenling *Hexagrammos stelleri*, are also well-known species. Close to the latter species is the *Abura ainame*, or

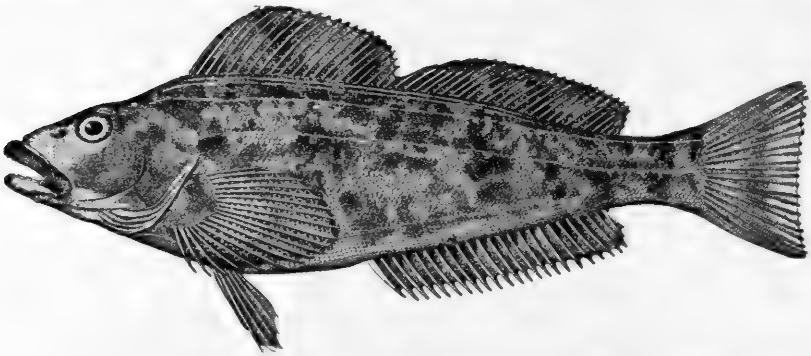


FIG. 379.—Greenling, *Hexagrammos decagrammus* (Pallas). Sitka.

fat cod, *Hexagrammos otakii*, common throughout Japan. The red rock-trout, *Hexagrammos superciliosus*, is beautifully variegated with red, the color being extremely variable. Other species are found in Japan and Kamchatka. *Agrammus agram-*

FIG. 380.—Cultus Cod, *Ophiodon elongatus* (Girard). Sitka, Alaska.

mus of Japan differs in the possession of but one lateral line. *Ophiodon elongatus*, the blue cod, cultus cod, or Buffalo cod of California, is a large fish of moderate value as food, much resembling a codfish, but with larger mouth and longer teeth. The flesh and bones are deeply tinged with bluish green. *Cultus* is the Chinnook name for worthless. *Zaniolepis latipinnis* is a singular-looking fish, very rough, dry, and bony, occasionally taken on the California coast. *Oxylebius pictus* is a small, handsome, and very active little fish, whitish with black bands, com-

mon among rocks and algæ on the California coast. It is, however, rarely brought into the markets, as it shows great skill in escaping the nets.

No fossil *Hexagrammidæ* are known.

The Flatheads or Kochi: Platycephalidæ.—The family of *Platycephalidæ* consists of spindle-shaped fishes, with flattened, rough heads and the body covered with small, rough scales. About fifty species occur in the East Indian region, where the larger ones are much valued as food. The most abundant species and usually the largest in size is *Platycephalus insidiator*, the kochi of the Japanese. The genus *Insidiator* contains smaller species with larger scales. In all these the head is very much depressed, a feature which separates them from all the *Scorpænidæ*. *Hoplichthys langsdorfi*, the nezupo or rat-tail of Japan, is the type of a separate family, *Hoplichthyidæ*, characterized by a bony armature of rough plates. *Bembras japonicus*, another little Japanese fish, with the ventrals advanced in position and the skin with rough plates, is the type of the family of *Bembradidæ*.

The Sculpins: Cottidæ.—The great family of *Cottidæ* or sculpins is one especially characteristic of the northern seas, where a great variety of species is found. These differ in general from the *Scorpænidæ*, from which they are perhaps derived, in the greater number of vertebræ and in the relative feebleness or degeneration of the spinous dorsal, the ventrals, and the scales. In all these regards great variation exists. In the most primitive genus, *Jordania*, the body is well scaled, the spinous dorsal well developed, and the ventral rays I, 5. In *Hemitripterus* a large number of dorsal spines remains, but the structure in other regards is highly modified. In the most degraded types, *Cottunculus*, *Psychrolutes*, *Gilbertidia*, which are also among the most specialized, there is little trace of spinous dorsal, the scales are wholly lost, and the ventral fin is incomplete. Most of the species of *Cottidæ* live on the bottom in shallow seas. Some are found in deep water and a few swarm in the rivers. All are arctic or subarctic, none being found to the south of Italy, Virginia, California, and Japan. None are valued as food, being coarse and tough. Scarcely any are found fossil.

Of the multitude of genera of *Cottidæ* we notice a few of the most prominent. *Jordania zonope*, a pretty little fish of Puget Sound, is the most primitive in its characters, being closely allied to the *Hexagrammidæ*.

Scorpænichthys marmoratus, the great sculpin, or cabezon, of California reaches a length of 2½ feet. It has the ventral rays

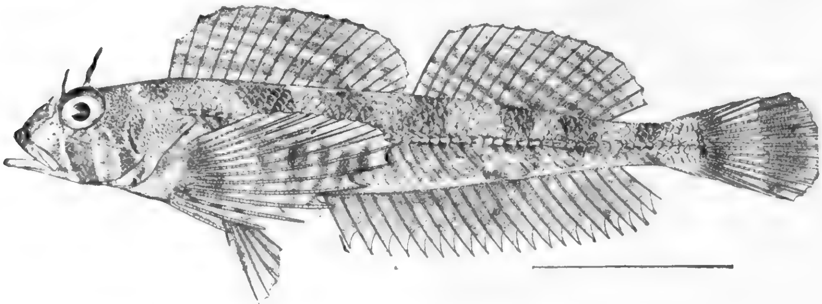


FIG. 381.—*Jordania zonope* Starks. Puget Sound.

1, 5, although almost in all the other sculpins the rays are reduced to 1, 3 or 1, 4. The flesh has the livid blue color seen in the cultus cod *Ophiodon elongatus*.

To *Icelinus*, *Artedius*, *Hemilepidotus*, *Astrolytes*, and related genera belong many species with the body partly scaled. These

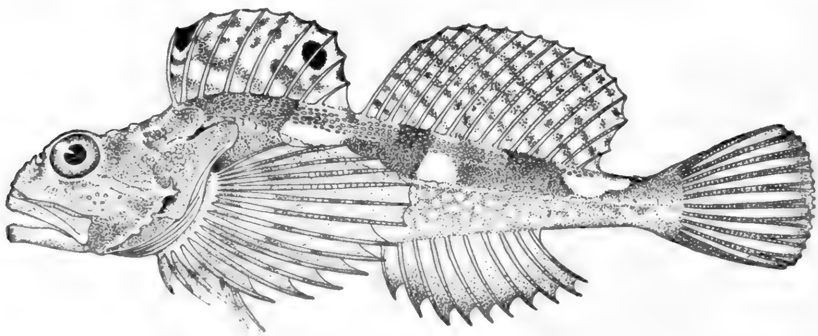


FIG. 382.—*Astrolytes notospilotus* (Girard). Puget Sound.

are characteristic of the North Pacific, in which they drop to a considerable depth. *Icelus*, *Triglops*, and *Artediellus* are found also in the North Atlantic, the Arctic fauna of which is derived almost entirely from Pacific sources. The genus *Hemilepidotus* contains coarse species, with bands of scales. The "Irish lord," *Hemilepidotus jordani*, a familiar and fantastic

inhabitant of Bering Sea, is much valued by the Aleuts as a food-fish, although the flesh is rather tough and without much

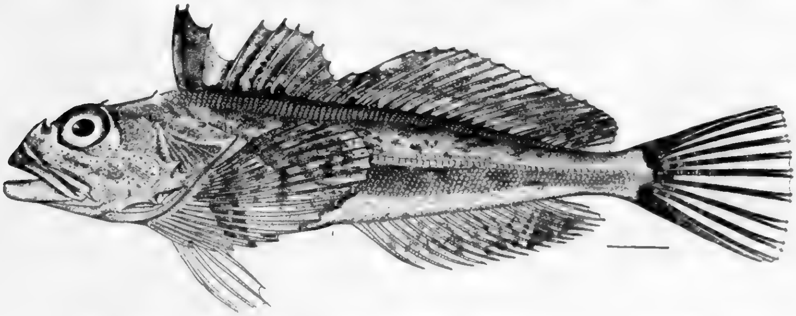


FIG. 383.—Irish Lord, *Hemilepidotus jordani* Bean. Unalaska.

flavor. Almost equally common in Bering Sea is the red sculpin, *Hemilepidotus hemilepidotus*, and the still rougher *Cera-*

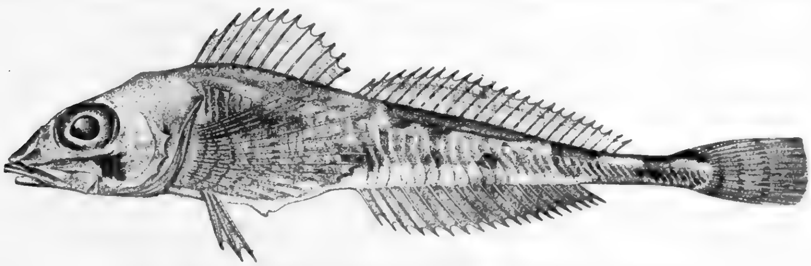


FIG. 384.—*Triglops pingeli* Kröyer. Chebucto, Canada.

tocottus diceraus. The stone-sculpin, or buffalo-sculpin, *Enophrys bison*, with bony plates on the side and rough horns on the preo-

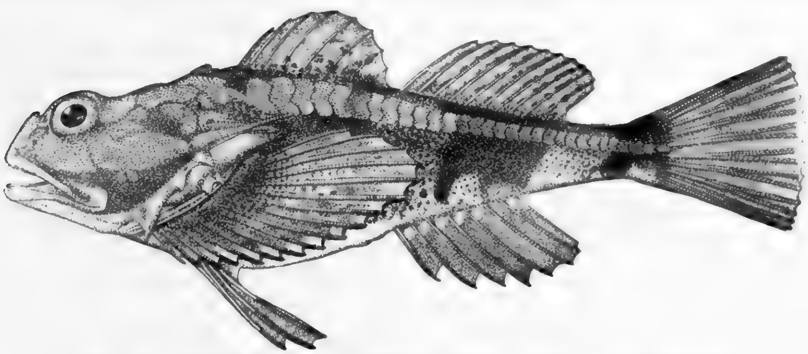


FIG. 385.—Buffalo Sculpin, *Enophrys bison* (Girard). Puget Sound.

percle, is found about Puget Sound and southward. In all these large rough species from the North Pacific the preopercle

is armed with long spines which are erected when the fish is disturbed. This makes it almost impossible for any larger fish to swallow them.

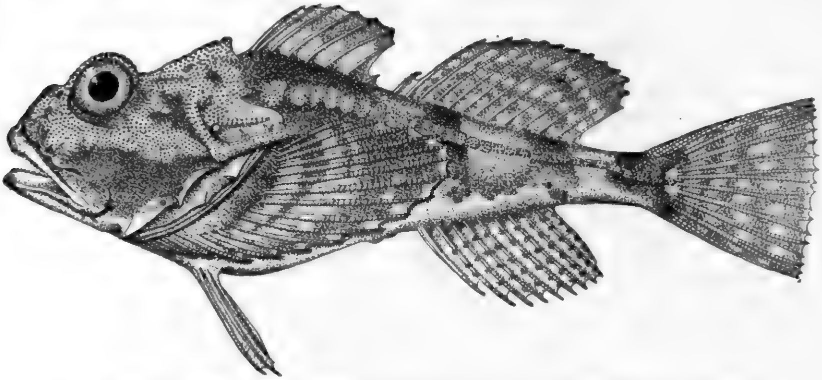


Fig. 386.—*Ceratocottus diceraus* (Cuv. & Val.). Tolstoi Bay, Alaska.

The genera *Cottus* and *Uranidea* include the miller's thumbs, also called in America, blob and muffle-jaws, of the Northern

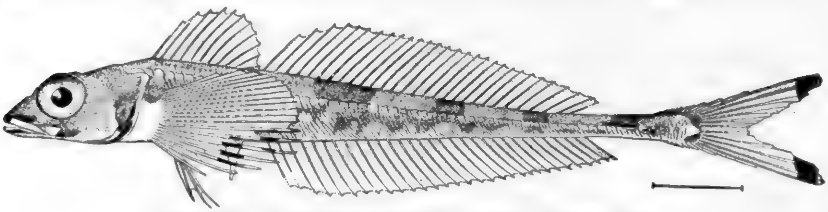


Fig. 387.—*Elanura forficata* Gilbert. Bering Sea.

rivers. These little fishes are found in Europe, Asia, and America wherever trout are found. They lurk under weeds and stones,

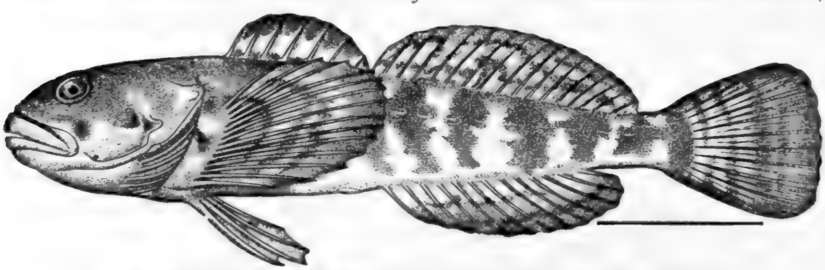


Fig. 388.—Yellowstone Miller's Thumb, *Cottus punctulatus* (Gill). Yellowstone River.

moving with the greatest swiftness when disturbed. They are found in every cold stream of the region north of Virginia, and they vie with the sticklebacks in their destruction of the eggs

and fry of salmon and trout. *Cottus gobio* is the commonest species of Europe. *Cottus ictalops* is the most abundant of the several species of the eastern United States, and *Cottus asper* in streams of the Pacific Coast, though very many other species

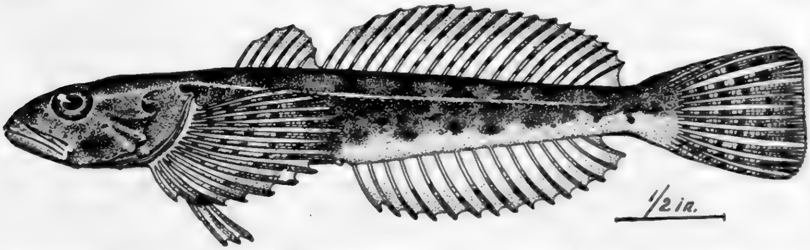


FIG. 389.—Miller's Thumb, *Uranidea tenuis* Evermann & Meek. Klamath Falls.

exist in each of these regions. The genus *Uranidea* is found in America. It is composed of smaller species with fewer teeth and fin-rays, the ventrals I, 3. *Uranidea gracilis* is the commonest of these, the miller's thumb of New England. *Rheopresbe fujiyamæ* is a large river sculpin in Japan.

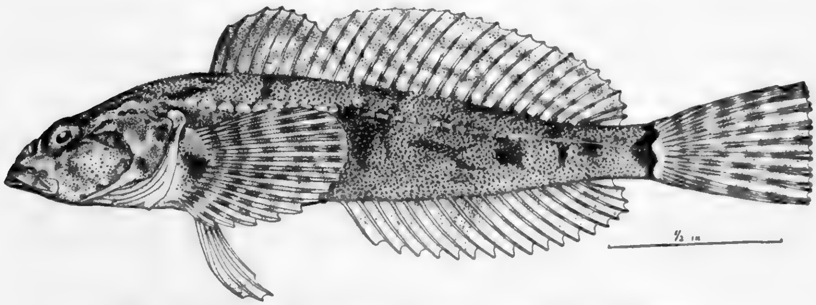


FIG. 390.—*Cottus evermanni* Gilbert. Lost River, Oregon.

Trachidermus ansatus is another river species, the "mountain-witch" (yama-no-kami) of Japan, remarkable for a scarlet brand on its cheek, conspicuous in life.

The chief genus of Atlantic sculpins is *Myoxocephalus*, containing large marine species, in structure much like the species of *Cottus*. *Myoxocephalus bubalis* is the European fatherlasher, or proach; the European sculpin is *Myoxocephalus scorpius*. The very similar daddy sculpin of New England is *Myoxocephalus grœnlandicus*. This species swarms everywhere from Cape Cod northward.

According to Fabricius, *Myoxocephalus grœnlandicus* is "abundant in all the bays and inlets of Greenland, but prefers a stony coast clothed with seaweed. It approaches the shore in

Fig. 391.—California Miller's Thumb, *Cottus gulosus* Girard. McCloud River, Cal. (Photograph by Cloudsley Rutter.)

spring and departs in winter. It is very voracious, preying on everything that comes in its way and pursuing incessantly the smaller fish, not sparing the young of its own species, and devouring crustacea and worms. It is very active and bold, but does not come to the surface unless it be led thither in pursuit of

Fig. 392.—Pribilof Sculpin, *Myoxocephalus niger* (Bean). St. Paul Island, Bering Sea.

other fish. It spawns in December and January and deposits its red-colored roe on the seaweed. It is easily taken with a bait, and constitutes the daily food of the Greenlanders, who are very fond of it. They eat the roe raw."

The little sculpin, or grubby, of the New England coast is *Myoxocephalus æneus*, and the larger eighteen-spined sculpin is *Myoxocephalus octodecimspinosus*. Still more numerous and

varied are the sculpins of the North Pacific, *Myoxocephalus polyacanthocephalus* being the best known and most widely diffused. *Oncocottus quadricornis* is the long-horned sculpin of the Arctic Europe, entering the lakes of Russia and British

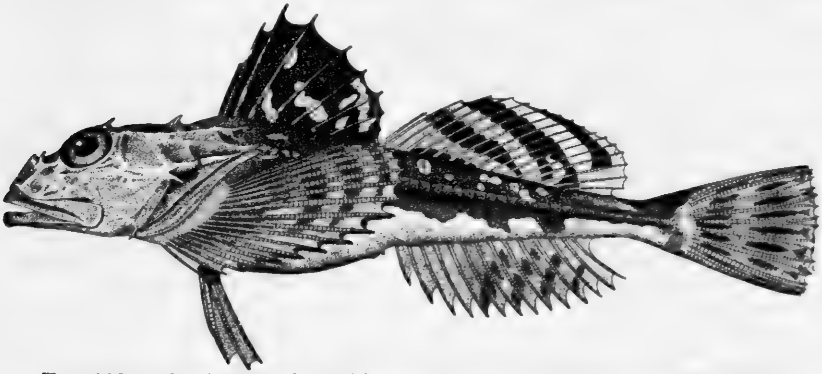


Fig. 393.—18-spined Sculpin, *Myoxocephalus octodecimspinosus* (Mitchill). Beasley Point, N. J.

America. *Triglopsis thompsoni* of the depths in our own Great Lakes seems to be a dwarfed and degenerate descendant of *Oncocottus*.

The genus *Zesticelus* contains small soft-bodied sculpins from the depths of the North Pacific. *Zesticelus profundorum* was

Fig. 394.—*Oncocottus quadricornis* (L.). St. Michael, Alaska.

taken in 664 fathoms off Bogoslof Island and *Zesticelus bathybius* off Japan. In this genus the body is very soft and the skeleton feeble, the result of deep-sea life. Another deep-water genus less degraded is *Cottunculus*, from which by gradual loss of fins the still more degraded *Psychrolutes* (*paradoxus*) and *Gilbertidia* (*sigolutes*) are perhaps descended. In sculpins of this type the liparids, or sea-snails, may have had their origin. Among the

remaining genera *Gymnocanthus* (*tricuspis*, etc.) has no vomerine teeth. *Leptocottus* (*armatus*) and *Clinocottus* (*analis*) abound on the coast of California, and *Pseudoblennius* (*percoides*) is

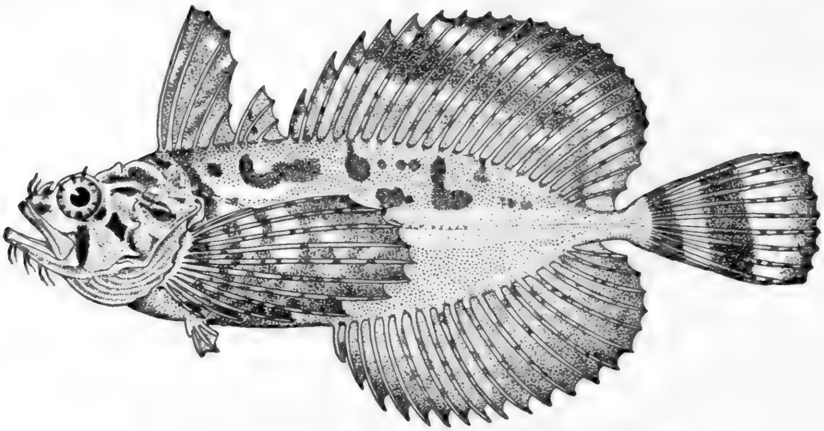


Fig. 395.—*Blepsias cirrhosus* Pallas. Straits of Fuca.

found everywhere along the shores of Japan. *Vellitor centropomus* of Japan is remarkable among sculpins for its compressed body and long snout. *Dialarchus snyderi* of the California rock-

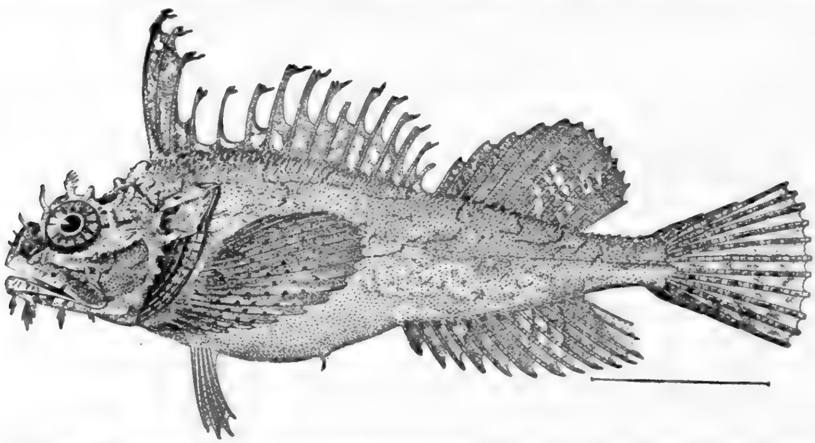


Fig. 396.—Sea raven, *Hemitripterus americanus* (Gmelin). Halifax, Nova Scotia.

pools is perhaps the smallest species of sculpin, *Blepsias* (*cirrhosus*), *Nautichthys* (*oculofasciatus*), and *Hemitripterus* (*americanus*), the sea-raven, among the most fantastic. In the last-named genus the spinous dorsal is many-rayed, as in *Scorpænidæ*, a fact which has led to its separation by Dr. Gill as a dis-

tinct family. But the dorsal spines are equally numerous in *Jordania*, which stands at the opposite extreme of the cottoid seires.

In *Ascelichthys* (*rhodorus*), a pretty sculpin of the rock-pools of the Oregon region, the ventral fins are wholly lost. *Ereunias grallator*, a deep-water sculpin from Japan, without ventrals and

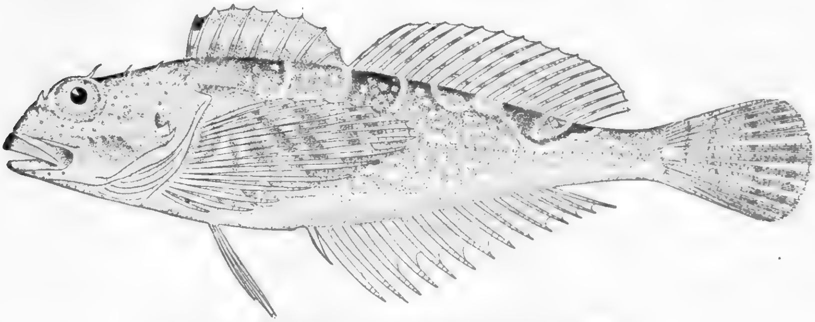


Fig. 397.—*Oligocottus maculosus* Girard. Sitka.

with free rays below its pectorals, should perhaps represent a distinct family, *Ereuniidæ*.

The degeneration of the spinous dorsal in *Psychrolutes* and *Gilbertidia* of the North Pacific has been already noticed. These genera seem to lead directly from *Cottunculus* to *Liparis*.

Fossil *Cottidæ* are few. *Eocottus veronensis*, from the Eocene of Monte Bolca, is completely scaled, with the ventral rays I, 5. It is apparently related to *Jordania*, but is still more primitive. *Lepidocottus* (*aries* and numerous other species, mostly from the Miocene) is covered with scales, but apparently has less than five soft rays in the ventrals. Remains of *Oncocottus*, *Icelus*, and *Cottus* are found in Arctic Pleistocene rocks. The family as a whole is evidently of recent date.

The *Rhamphocottidæ* consist of a single little sculpin with a large bony and singularly formed head, found on the Pacific Coast from Sitka to Monterey. The species is called *Rhamphocottus richardsoni*.

The Sea-poachers: Agonidæ.—The sea-poachers or alligator-fishes, *Agonidæ*, are sculpins inclosed in a coat of mail made by a series of overlying plates, much like those of the sea-horses or the catfishes of the family *Loricariidæ*. So far as structure goes, these singular fishes are essentially like the *Cottidæ*, but

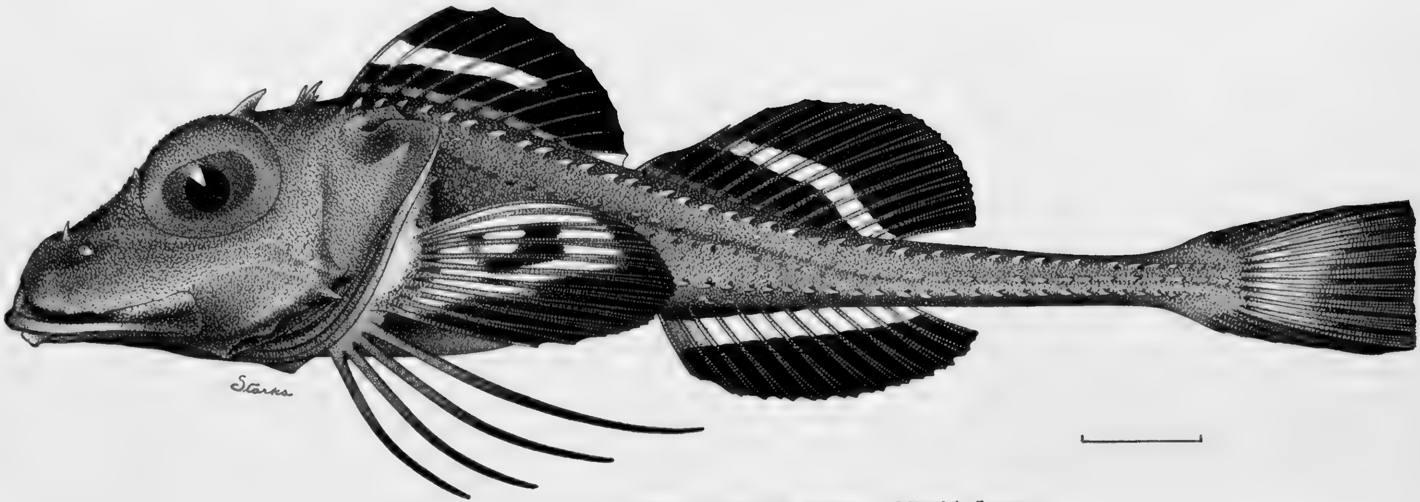


FIG. 39.—*Ereunias grallator* Jordan & Snyder. Misaki, Japan.

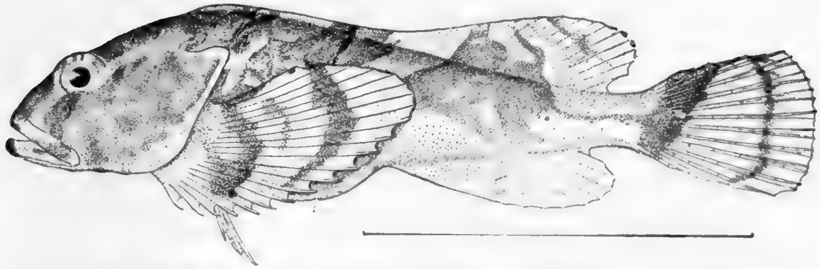


FIG. 399.—Sleek Sculpin, *Psychrolutes paradoxus* (Günther). Puget Sound.

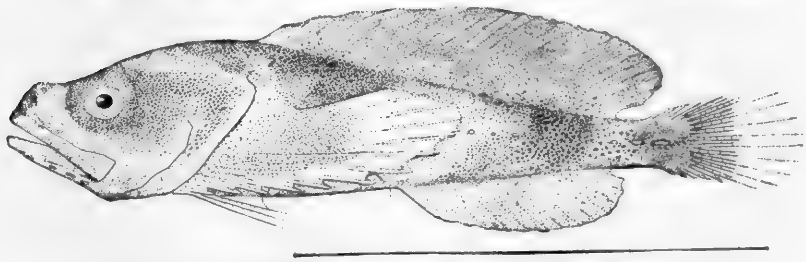


FIG. 400.—*Gilbertidia sigolutes* (Jordan). Puget Sound.

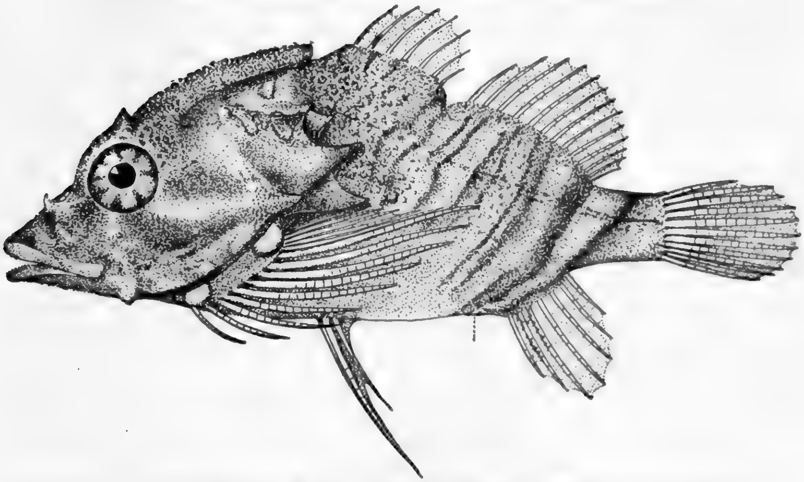


FIG. 401.—Richardson's Sculpin, *Rhamphocottus richardsoni* (Günther). Puget Sound.

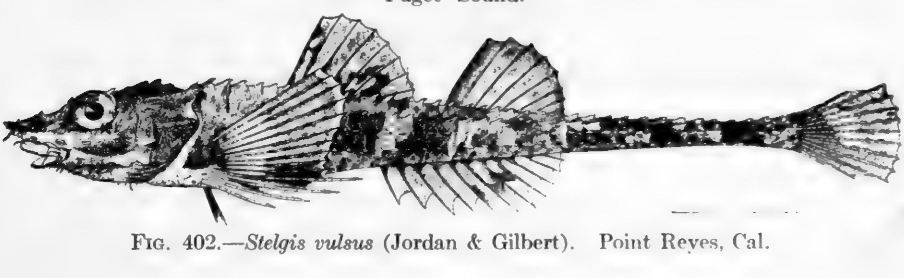


FIG. 402.—*Stelgis vulsus* (Jordan & Gilbert). Point Reyes, Cal.

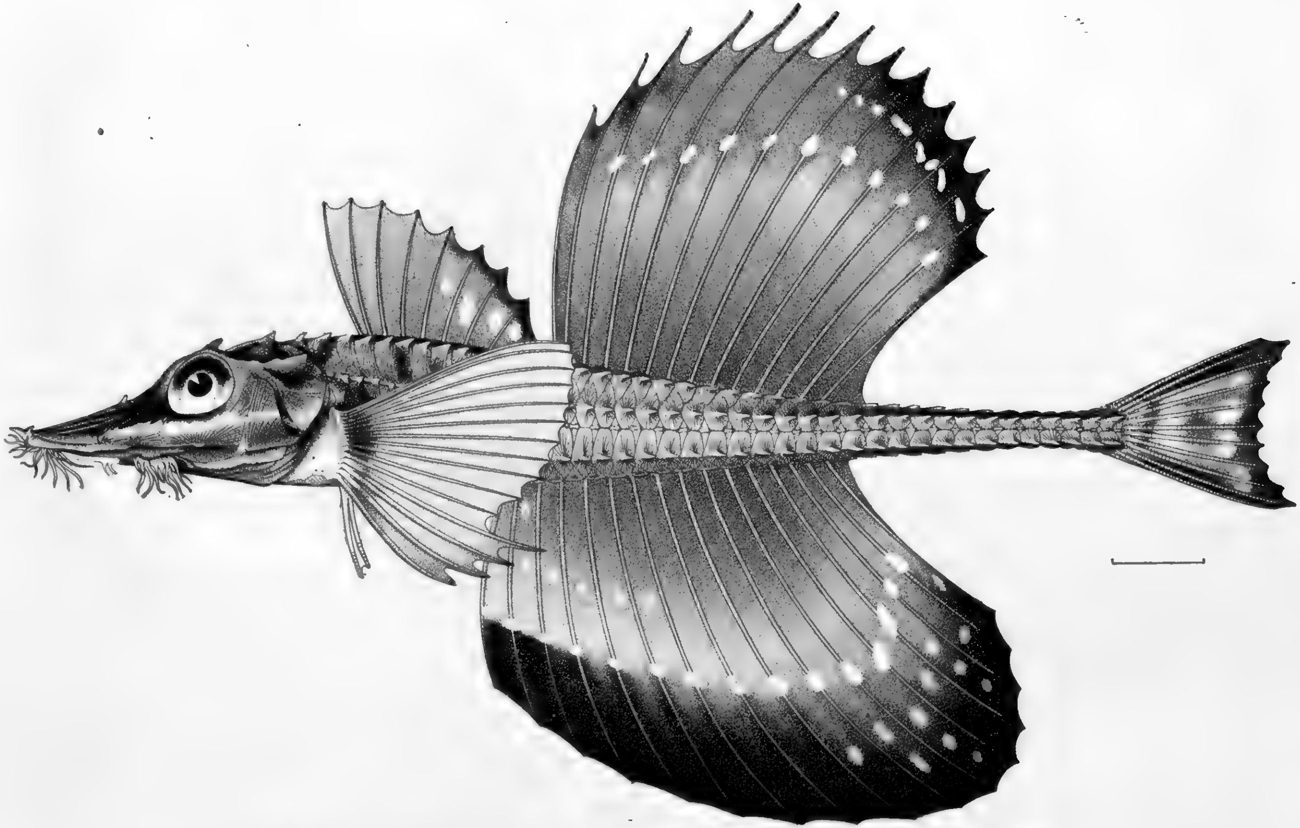


FIG. 403.—*Draciscus sachi* Jordan & Snyder. Family *Agonidæ*. Aomori, Japan.

with a different and more perfect armature. The many species belong chiefly to the North Pacific, a few in the Atlantic and on the coast of Patagonia. Some are found in considerable depth of water. All are too small to have value as food and some have

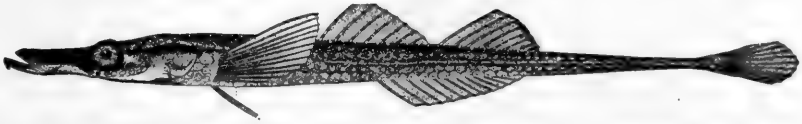


Fig. 404.—Agonoid-fish, *Pallasina barbata* (Steindachner). Port Mulgrave, Alaska

most fantastic forms. Only a few of the most prominent need be noticed. The largest and most peculiar species is *Percis japonicus* of the Kurile Islands. Still more fantastic is the Japanese *Draciscus sachi* with sail-like dorsal and anal. *Agonus cataphractus*, the sea-poacher, is the only European species. *Podothecus acipenserinus*, the alligator-fish, is the commonest species of the North Pacific. *Pallasina barbata* is as slender as

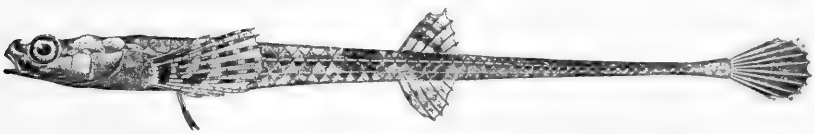


Fig. 405.—*Aspidophoroides monopterygius* (Bloch). Halifax.

a pipefish, with a short beard at the chin. *Aspidophoroides monopterygius* of the Atlantic and other similar species of the Pacific lack the spinous dorsal fin.

No fossil *Agonidæ* are known.

The Lump-suckers: Cyclopteridæ. — The lump-suckers, *Cyclopteridæ*, are structurally very similar to the *Cottidæ*, but of very different habit, the body being clumsy and the movements very slow. The ventral fins are united to form a sucking disk by which these sluggish fishes hold fast to rocks. The skeleton is feebly ossified, the spinous dorsal fin wholly or partly lost, the skin smooth or covered with bony warts. The slender subortal stay indicates the relation of these fishes with the *Cottidæ*. The species are chiefly Arctic, the common lump-fish or "cock and hen paddle," *Cyclopterus lumpus*, abounding on both shores of the North Atlantic. It reaches a length of twenty inches, spawning in eel-grass where the male is left to

watch the eggs. *Cyclopterichthys ventricosus* is a large species with smooth skin from the North Pacific.

The Sea-snails: Liparididæ.—The sea-snails, *Liparididæ* are closely related to the lumpfishes, but the body is more elongate,

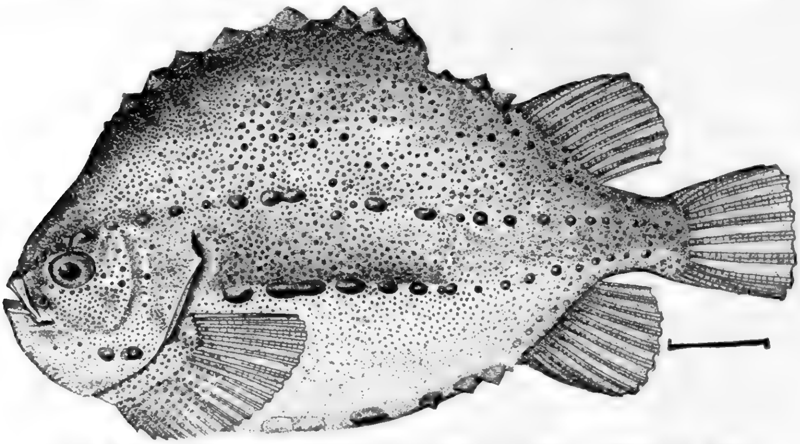


Fig. 406.—Lumpfish, *Cyclopterus lumpus* (Linnæus). Eastport, Me.

tadpole shaped, covered with very lax skin, like the "wrinkled skin on scalded milk." In structure the liparids are still more degenerate than the lumpfishes. Even the characteristic ven-

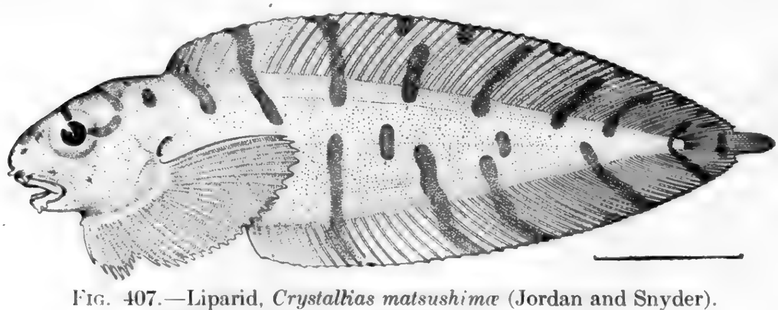


Fig. 407.—Liparid, *Crystallias matsushimæ* (Jordan and Snyder). Family *Liparididæ*. Matsushima Bay, Japan.

tral disk is lost in some species (*Paraliparis; Amitra*) and in numerous others the tail is drawn out into a point (leptocercal), a character almost always a result of degradation. The dorsal spines are wanting or imbedded in the loose skin, and all trace of spines on the head is lost, but the characteristic suborbital stay is well developed. The numerous species are all small, three to twelve inches in length. They live in Arctic waters,

often descending to great depths, in which case the body is very soft. One genus, *Enantioliparis*, is found in the Antarctic. In the principal genus, *Liparis*, the ventral disk is well developed, and the spinous dorsal obsolete. *Liparis liparis* is found on both shores of the North Atlantic, and is subject to large variations in color. *Liparis agassizi* is abundant in Japan and northward, and *Liparis pulchellus* in California. In the most primitive genus, *Neoliparis*, a notch in the fin indicates the separation of the spinous dorsal. *Neoliparis montagui* is common in Europe, replaced in New England by *Neoliparis atlanticus*. *Careproctus*, with numerous elongate species, inhabits depths of the North Pacific. In *Paraliparis* (or *Hilgendorfia*) *ulochir*, the ventral

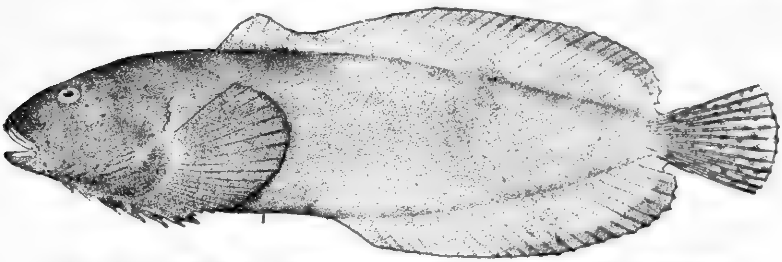


Fig. 408.—Snailfish, *Neoliparis mucosus* (Ayres). San Francisco.

disk is gone and the lowest stage of degradation of the Loricate or *Scorpæna-Cottus* type of fishes is reached. No fossil lump-suckers or liparids are recorded, although remains of *Cyclopterus lumpus* are found in nodules of glacial clay in Canada.

The Baikal Cods: Comephoridæ.—The family of *Comephoridæ* includes *Comephorus baikalensis*, a large fresh-water fish of Lake Baikal in Siberia, having no near affinities with any other existing fish, but now known to be a mail-cheek fish related to the *Cottidæ*. The body is elongate, naked, with soft flesh and feeble skeleton. The mouth is large, with small teeth, and the skull has a cavernous structure. There are no ventral fins. The spinous dorsal is short and low, the second dorsal and anal many-rayed, and the pectoral fins are excessively long, almost wing-like; the vertebræ number $8+35=43$, and unlike most fresh-water fishes, the species has no air-bladder. Little is known of the habits of this singular fish. Another genus is recently described under the name of *Cottocomephorus*.

Suborder Craniomi: the Gurnards, Triglidæ.—A remarkable offshoot from the *Pareioplitæ* is the suborder of gurnards, known as *Craniomi* (κράνιον, skull; ὦμος, shoulder). In these fishes the suborbital stay is highly developed, much as in the *Agonidæ*, bony externally and covering the cheeks. The shoulder-girdle is distorted, the post-temporal being solidly united to the cranium, while the postero-temporal is crowded out of place by the side of the proscapula. In other regards these fishes resemble the other mail-cheek forms, their affinities being perhaps closest with the *Agonidæ* or certain aberrant *Cottidæ* as *Ereunias*.

In the true gurnards or *Triglidæ* the head is rough and bony, the body covered with rough scales and below the pectoral fin are three free rays used as feelers by the fish as it creeps along the bottom. These free rays are used in turning over stones, exploring shells and otherwise searching for food. The numerous species are found in the warm seas. In Europe,

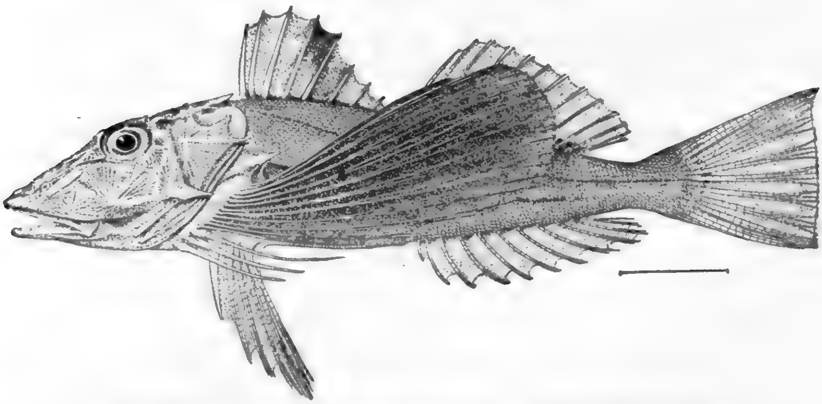


FIG. 409.—Sea-robin, *Prionotus evolans* (L.). Wood's Hole, Mass.

the genus *Trigla*, without palatine teeth and with the lateral line armed, is represented by numerous well-known species. *Trigla cuculus* is a common form of the Mediterranean. *Chelidonichthys*, similar to *Trigla* but larger and less fully armed, is found in Asia as well as in Europe. Several species occur in the Mediterranean. *Chelidonichthys kumu* is a common species in Japan, a large fish with pectorals of a very brilliant variegated blue, like the wings of certain butterflies.

Lepidotrigla, with larger scales, has many species on the coasts of Europe as well as in China and Japan. *Lepidotrigla*

alata, a red fish with a peculiar bony, forked snout, is common in Japan. The American species of gurnards, having teeth on the palatine, belong to the genus *Prionotus*. Northward these fishes, known as sea-robins, live along the shores in

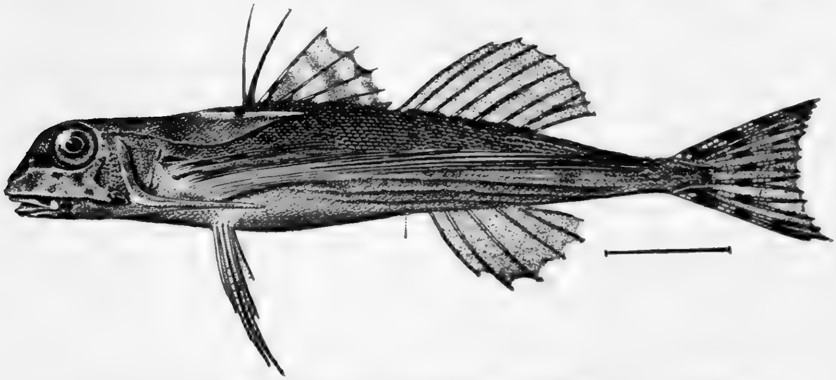


FIG. 410.—Flying Gurnard, *Cephalacanthus volitans* (L.). Virginia.

shallow water. In the tropics they descend to deeper water, assuming a red color. *Prionotus carolinus* is the commonest species in New England. *Prionotus strigatus*, the striped sea-robin, and *Prionotus tribulus*, the rough-headed sea-robin, are common species along the Carolina coast. None have much value as food, being dry and bony. Numerous fossil species

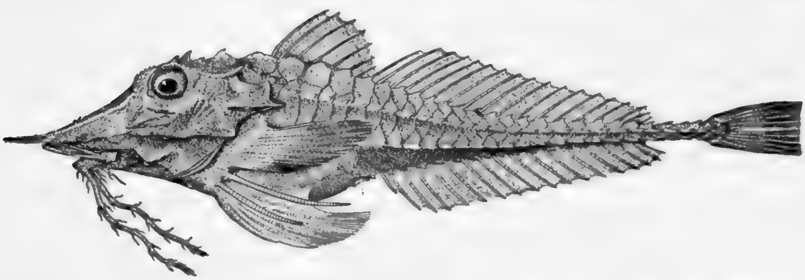


FIG. 411.—*Peristedion miniatum* Goode & Bean. Depths of the Gulf Stream.

referred to Trigla are found in the Miocene. *Podopteryx*, from the Italian Miocene, with small pectorals and very large ventrals, perhaps belongs also to this family, but its real affinities are unknown.

The Peristediidæ.—The *Peristediidæ* are deep-water sea-robins, much depressed, with flat heads, a bony coat of mail,

and two free feelers on the pectoral fin instead of three. The species of *Peristedion* are occasionally taken with the dredge. *Peristedion cataphractum* is rather common in Europe. The extinct *Peristedion urcianense* is described from the Pliocene of Orciano, Tuscany.

The Flying Gurnards: Cephalacanthidæ. — The flying gurnards, *Cephalacanthidæ*, differ in numerous respects and are among the most fantastic inhabitants of the sea. The head is short and bony, the body covered with firm scales, and the very long, wing-like pectoral fin is divided into two parts, the posterior and larger almost as long as the rest of the body. This fin is beautifully colored with blue and brownish red. The first spine of the dorsal fin is free from the others and more or less prolonged. The few species of flying gurnard are much alike, ranging widely in the tropical seas, and having a slight power of flight. The flying robin, or batfish, called in Spanish volador or murcielago, *Cephalacanthus volitans*, is common on both coasts of the Atlantic, reaching a length of eighteen inches. *Cephalacanthus peterseni* is found in Japan and *Cephalacanthus orientalis* in the East Indies, Japan, and Hawaii. The immature fishes have the pectoral fins much shorter than in the adult, and differ in other regards. *Cephalacanthus pliocenicus* occurs in the Lower Pliocene of Orciano, Tuscany.

Petalopteryx syriacus, an extinct flying gurnard found in the Cretaceous of Mount Lebanon, is an ally of *Cephalacanthus*. The body is covered with four-angled bony plates, and the first (free) spine of the dorsal is enlarged.

CHAPTER XXVI

GOBIOIDEI, DISCOCEPHALI, AND TÆNIOSOMI

SUBORDER Gobioidei, the Gobies: Gobiidæ.—The great family of *Gobiidæ*, having no near relations among the spiny-rayed fishes, may be here treated as forming a distinct suborder.

The chief characteristics of the family are the following: The ventral fins are thoracic in position, each having one spine and five soft rays, in some cases reduced to four, but never wanting. The ventral fins are inserted very close together, the inner rays the longest, and in most cases the two fins are completely joined, forming a single roundish fin, which may be used as a sucking-disk in clinging to rocks. The shoulder-girdle is essentially perch-like in form, the cranium is usually depressed, the bones being without serrature. There is no lateral line, the gill-openings are restricted to the sides, and the spinous dorsal is always small, of feeble spines, and is sometimes altogether wanting. There is no bony stay to the preopercle. The small pharyngeals are separate, and the vertebræ usually in normal number, $10 + 14 = 24$.

The species are excessively numerous in the tropics and temperate zones, being found in lakes, brooks, swamps, and bays, never far out in the sea, and usually in shallow water. Many of them burrow in the mud between or below tide-marks. Others live in swift waters like the darters, which they much resemble. A few reach a length of a foot or two, but the most of the species rarely exceed three inches, and some of thme are mature at half an inch.

The largest species, *Philypnus dormitor*, the guavina de rio, is found in the rivers of Mexico and the West Indies. It reaches a length of nearly two feet and is valued as food. Unlike most of the others, in this species there are

teeth on the vomer. Other related forms of the subfamily of *Eleotrinæ*, having the ventral fins separate, are *Eleotris pisonis*, a common river-fish everywhere in tropical America; *Eleotris fusca*, a river-fish abounding from Tahiti and Samoa

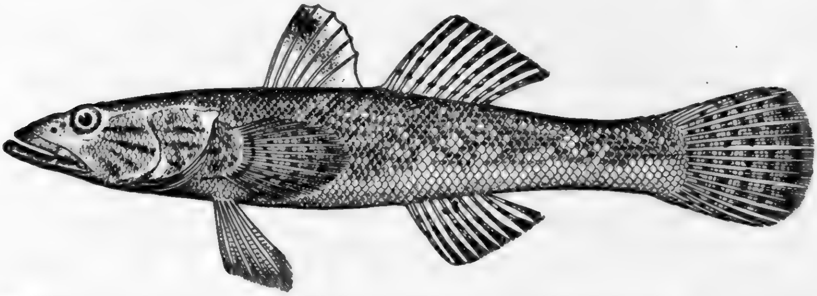


Fig. 412.—Guavina de Rio, *Philypnus dormitor* (Bloch & Schneider). Puerto Rico.

to Hindostan; *Dormitator maculatus*, the stout-bodied guavina-mapo of the West Indian regions, with the form of a small carp. *Guavina guavina* of Cuba is another species of this type, and numerous other species having separate ventrals are found in the East Indies, the West Indies, and in the islands of Polynesia. Some species, as *Valenciennesia strigata* of the East

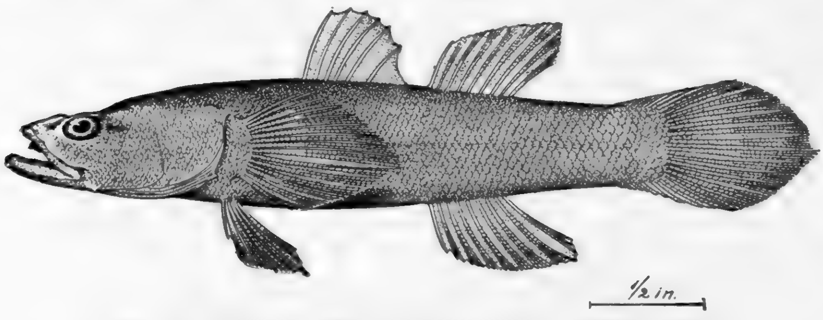


Fig. 413.—Dormeur, *Eleotris pisonis* Gmelin. Tortugas, Fla.

Indies and *Vireosa hanæ* of Japan, are very gracefully colored. One genus, *Eviota*, is composed of numerous species, all minute, less than an inch in length. These abound in the crevices in coral-heads. *Eviota epiphanes* is found in Hawaii, the others farther south. *Hypseleotris guntheri*, of the rivers and springs of Polynesia, swims freely in the water, like a minnow, never hugging the bottom as usual among gobies.

Of the typical gobies having the ventrals united we can mention but a few of the myriad forms, different species being

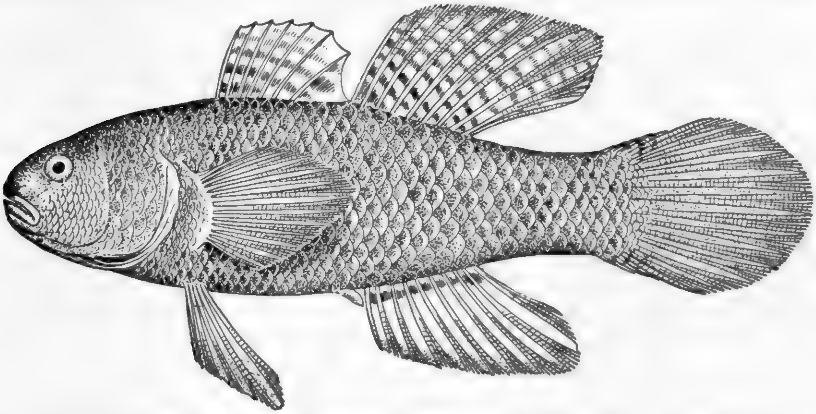


Fig. 414.—Guavina mapo, *Dormitator maculatus* (Schneider). Puerto Rico.

abundant alike in fresh and salt waters in all warm regions. In Europe *Gobius jozo*, *Gobius ophiocephalus*, and many others

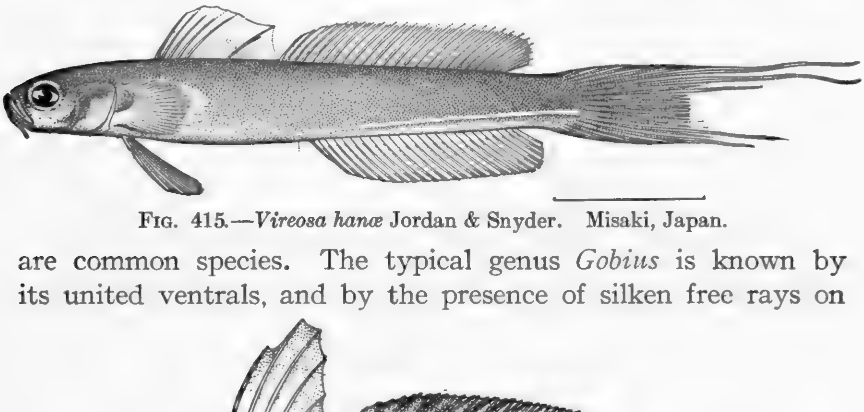


Fig. 415.—*Vireosa hanæ* Jordan & Snyder. Misaki, Japan.

are common species. The typical genus *Gobius* is known by its united ventrals, and by the presence of silken free rays on

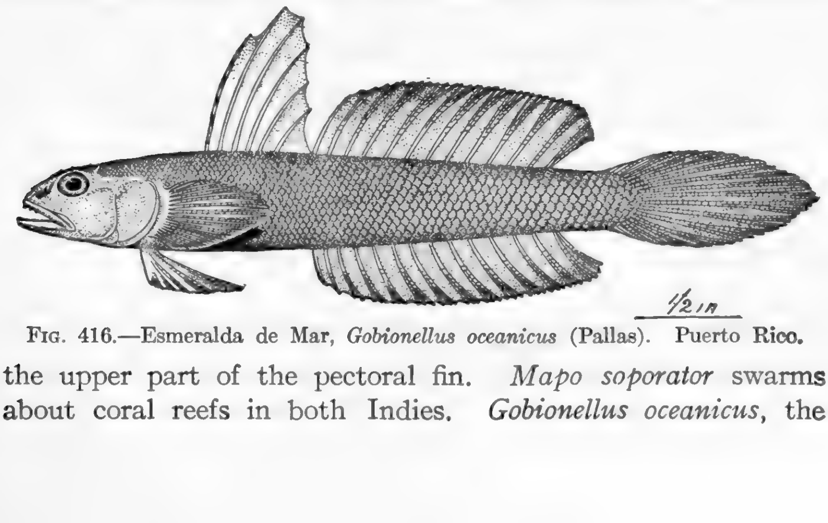


Fig. 416.—Esmeralda de Mar, *Gobionellus oceanicus* (Pallas). Puerto Rico.

the upper part of the pectoral fin. *Mapo soporator* swarms about coral reefs in both Indies. *Gobionellus oceanicus*, the

esmeralda or emerald-fish, is notable for its slender body and the green spot over its tongue. *Gobiosoma alepidotum* and other species are scaleless. *Barbulifer ceuthœcus* lives in the cavities of sponges. *Coryphopterus similis*, a small goby, swarms in almost every brook of Japan. The species of *Ptero-*

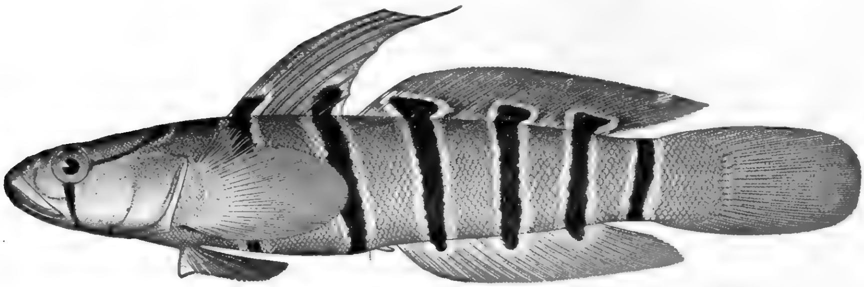


FIG. 417.—*Pterogobius daimio* Jordan & Snyder. Misaki, Japan.

gobius are beautifully colored, banded with white or black, or striped with red or blue. *Pterogobius virgo* and *Pterogobius daimio* of Japan are the most attractive species. Species of *Cryptocentrus* are also very prettily colored.

Of the species burrowing in mud the most interesting is the long-jawed goby, *Gillichthys mirabilis*. In this species

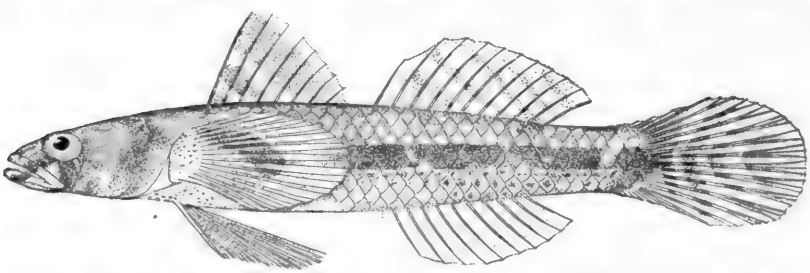


FIG. 418.—Darter Goby, *Aboma etheostoma* Jordan. Mazatlan, Mex.

the upper jaw is greatly prolonged, longer than the head, as in *Opisthognathus* and *Neoclinus*. In the "American Naturalist" for August, 1877, Mr. W. N. Lockington says of the long-jawed goby:

"I call it the long-jawed goby, as its chief peculiarity consists in its tremendous length of jaw. A garpike has a long jaw, and so has an alligator, and it is not unlikely that the title will call up in the minds of some who read this the idea of a terrible

mouth, armed with a bristling row of teeth. This would be a great mistake, for our little fish has no teeth worth bragging about, and does not open his mouth any wider than a well-behaved fish should do. The great difference between his long jaws and those of a garpike is that the latter's project forward, while those of our goby are prolonged backward immensely.

"The long-jawed goby was discovered by Dr. J. G. Cooper in the Bay of San Diego, among seaweed growing on small stones at the wharf, and in such position that it must have been out of the water from three to six hours daily, though kept moist by the seaweed.

"On a recent occasion a single *Gillichthys*, much larger than any of the original types, was presented by a gentleman who said that the fish, which was new to him, was abundant upon his ranch in Richardson's Bay, in the northern part of the Bay of San Francisco; that the Chinamen dug them up and ate them, and that he had had about eleven specimens cooked,

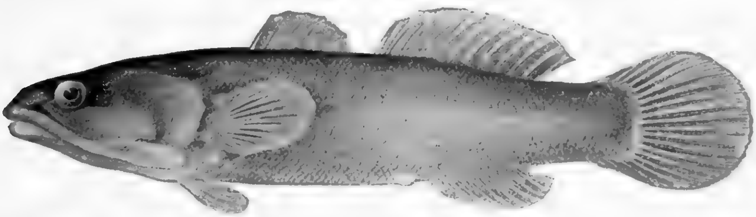


Fig. 419.—Long-jawed Goby. *Gillichthys mirabilis* Cooper. Santa Barbara.

and found them good, tasting, he thought, something like eels. The twelfth specimen he had preserved in alcohol, in the interest of natural science. This gentleman had the opportunity of observing something of the mode of life of these fishes, and informed us that their holes, excavated in the muddy banks of tidal creeks, increase in size as they go downward, so that the lower portion is below the water-level, or at least sufficiently low to be kept wet by the percolation from the surrounding mud.

"When the various specimens now acquired were placed side by side, the difference in the relative length of their jaws was very conspicuous, for while in the smallest it was about one-fifth of the total length, in the largest it exceeded one-third.

"As the fish had now been found in two places in the bay,

I thought I would try to find it also, and to this end sallied out one morning, armed with a spade, and commenced prospecting in a marsh at Berkeley, not far from the State University. For a long time I was unsuccessful, as I did not know by what outward signs their habitations could be distinguished, and the extent of mud-bank left bare by the retreating tide was, as compared with my powers of delving, practically limitless.

"At last, toward evening, while digging in the bend of a small creek, in a stratum of soft, bluish mud, and at a depth of about a foot below a small puddle, I found five small fishes, which at first I believed to belong to an undescribed species, so little did they resemble the typical *G. mirabilis*, but which proved, upon a closer examination, to be the young of that species. There was the depressed, broad head, the funnel-shaped ventral 'disk' formed by the union of the two ventral fins, and the compressed tail of the long-jawed goby, but where were the long jaws? The jaws were, of course, in their usual place, but their prolongations had only just begun to grow along the sides of the head, and were not noticeable unless looked for. A comparison of the various specimens proved conclusively that the strange-looking appendage is developed during the growth of the fish, as will be seen by the following measurements of four individuals:

"In the smallest specimen the maxillary expansion extends beyond the orbit for a distance about equal to that which intervenes between the anterior margin of the orbit and the tip of the snout; in No. 2 it reaches to the posterior margin of the preoperculum; in No. 3 it ends level with the gill-opening; while in the largest individual it passes the origin of the pectoral and ventral fins.

"What can be the use of this long fold of skin and cartilage, which is not attached to the head except where it joins the mouth, and which, from its gradual development and ultimate large dimensions, must certainly serve some useful purpose?

"Do not understand that I mean that every part of a creature is of use to it in its present mode of life, for, as all naturalists know, there are in structural anatomy, just as in social life, cases of *survival;* remains of organs which were at some

former time more developed, parallel in their nature to such survivals in costume as the two buttons on the back of a man's coat, once useful for the attachment of a sword-belt. But in this fish we have no case of survival, but one of unusual development; the family (*Gobiidæ*) to which it belongs presents no similar case, although its members have somewhat similar habits, and the conviction grows upon us, as we consider the subject, that the long jaws serve some useful purpose in the economy of the creature. In view of the half-terrestrial life led by this fish, I am inclined to suspect that the expansion of the upper jaw may serve for the retention of a small quantity of water, which, slowly trickling downward into the mouth and gills, keeps the latter moist when, from an unusually low tide or a dry season, the waters of its native creek fail, perhaps for several hours, to reach the holes in which the fishes dwell. It may be objected to this view that, were such an appendage necessary or even useful, other species of *Gobiidæ*, whose habits are similar, would show traces of a similar adaptation. This, however, by no means follows. Nature has many ways of working out the same end; and it must be remembered that every real species, when thoroughly known, differs somewhat in habits from its congeners, or at least from its family friends. To take an illustration from the mammalia. The chimpanzee and the spider-monkey are both quadrumanous and both arboreal, yet the end which is attained in the former by its more perfect hands is reached in the latter by its prehensile tail.

"Why may not the extremely long channel formed by the jaw of this rather abnormal member of the goby family be another mode of provision for the requirements of respiration?"

Of the Asiatic genera, *Periophthalmus* and *Boleophthalmus* are especially notable. In these mud-skippers the eyes are raised on a short stalk, the fins are strong, and the animal has the power of skipping along over the wet sands and mud, even skimming with great speed over the surface of the water. It chases its insect prey among rocks, leaves, and weeds, and out of the water is as agile as a lizard. Several species of these mud-skippers are known on the coasts of Asia and Polynesia, *Periophthalmus barbarus* and *Boleophthalmus chinensis* being the best known. *Awaous crassilabris* is the common oopu, or

river goby, of the Hawaiian streams, and *Lentipes stimpsoni* is the mountain oopu, capable of clinging to the rocks in the

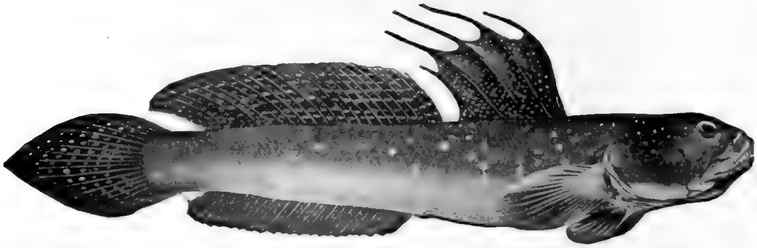


FIG. 420.—Pond-skipper, *Boleophthalmus chinensis* (Osbeck). Bay of Tokyo, Japan. (Eye-stalks sunken in preservation.)

rush of torrents. *Paragobiodon echinocephalus* is a short thick-set goby with very large head, found in crevices of coral reefs of Polynesia.

FIG. 421.—Mud-skippy, *Periophthalmus barbarus* (L.). Mouth of Vaisigono River, Apia, Samoa.

In numerous interesting species the first dorsal fin is wanting or much reduced. The crystal goby, *Crystallogobius nilssoni*, of Europe is one of this type, with the body translucent. Equally

translucent is the little Japanese shiro-uwo, or whitefish, *Leucopsarion petersi*. *Mistichthys luzonius* of the Philippine Islands, another diaphanous goby, is said to be the smallest of all vertebrates, being mature at half an inch in length. This minute fish is so very abundant as to become an important article of food in Luzon. The rank of "smallest-known vertebrate" has been claimed in turn for the lancelet (*Asymmetron lucayanum*), the top minnow, *Heterandria formosa*, and the dwarf sunfish (*Elassoma zonatum*). *Mistichthys luzonius* is smaller than any of these, but the diminutive gobies, called *Eviota*, found in interstices of coral rocks are equally small, and there are several brilliant but minute forms in the reefs of Samoa. The snake-like *Eutæniichthys gilli* of Japanese rivers is scarcely larger, though over an inch long. *Typhogobius californiensis*, "the blindfish of Point Loma," is a small goby, colorless and blind, found clinging in dark crevices of rock about Point Loma and Dead Man's Island in southern California.

Its eyes are represented by mere rudiments, their loss being evidently associated with the peculiar habit of the species,

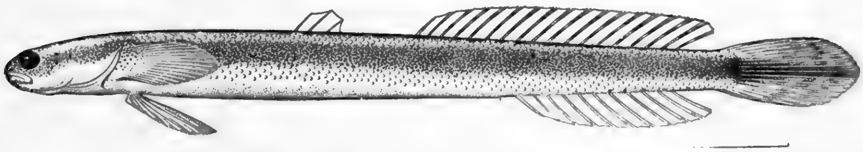


Fig. 422.—*Eutæniichthys gillii* Jordan & Snyder. Tokyo, Japan.

which clings to the under side of stones in relative darkness, though in very shallow water. The flesh is also colorless, the animal appearing pink in life.

In the Japanese species *Luciogobus guttatus*, common under stones and along the coast, the spinous dorsal, weak in numerous other species, finally vanishes altogether. Other gobies are band-shaped or eel-shaped, the dorsal spines being continuous with the soft rays. Among these are the barreto of Cuba, *Gobioides broussoneti*, and in Japan *Tænioides lacepedei* and *Trypauchen wakæ*, the latter species remarkable for its strong canines. Fossil gobies are practically unknown. A few fragments, otoliths, and partial skeletons in southern Europe have been referred to *Gobius*, but no other genus is represented.

The family of *Oxudercidæ* contains one species, *Oxuderces dentatus*, a small goby-like fish from China. It is an elongate fish, without ventral fins, and with very short dorsal and anal.

Suborder Discocephali, the Shark-suckers: Echeneididæ.—Next to the gobies, for want of a better place, we may mention the singular group of *Discocephali* (δίσκος, disk; κεφηλή, head). In this group the first dorsal fin is transformed into a peculiar laminated sucking-disk, which covers the whole top of the head and the nape. In other respects the structure does not diverge very widely from the percoid type, there being a remarkable resemblance in external characters to the Scombroid genus *Rachycentron*. But the skeleton shows no special affinity to *Rachycentron* or to any perciform fish. The basis of the cranium is

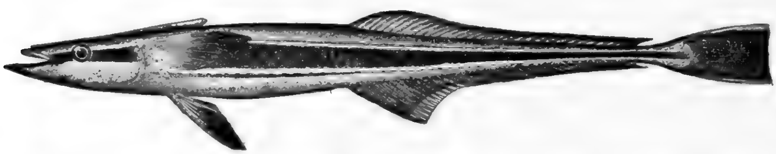


FIG. 423—Sucking-fish, or Pegador, *Leptecheneis naucrates* (Linnæus). Virginia.

simple, and in the depression of the head with associated modifications the *Discocephali* approach the gobies and blennies rather than the mackerel-like forms.

The *Discocephali* comprise the single family of shark-suckers or remoras, the *Echeneididæ*. All the species of this group are pelagic fishes, widely diffused in the warm seas. All cling by their cephalic disks to sharks, barracudas, and other free-swimming fishes, and are carried about the seas by these. They do not harm the shark except by slightly impeding its movement. They are carnivorous fishes, feeding on sardines, young herring, and the like. When a shark, taken on the hook, is drawn out of the water the sucking-fish leaves it instantly, and is capable of much speed in swimming on its own account. These fishes are all dusky in color, the belly as dark as the back, so as to form little contrast to the color of the shark.

The commonest species, *Leptecheneis naucrates*, called pega-pega or pegador in Cuba, reaches a length of about two feet and is almost cosmopolitan in its range, being found exclusively on the larger sharks, notably on *Carcharias lamia*. It has

20 to 22 plates in its disk, and the sides are marked by a dusky lateral band.

Almost equally widely distributed is the smaller remora, or shark-sucker (*Echeneis remora*), with a stouter body and about 18 plates in the cephalic disk. This species is found in Europe, on the coast of New York, in the West Indies, in California, and in Japan, but is nowhere abundant. Another widely distributed species is *Remorina albescens* with 13 plates in its disk. *Remoropsis brachyptera*, with 15 plates and a long soft dorsal, is also occasionally taken. *Rhombochirus osteochir* is a rare species of the Atlantic with 18 plates, having the pec-

FIG. 424.—*Rhombochirus osteochir* (Cuv. & Val.). Wood's Hole, Mass.

toral rays all enlarged and stiff. The louse-fish (*Phtheirichthys lineatus*) is a small and slender remora having but 10 plates in its disk. It is found attached, not to sharks, but to barracudas and spearfishes.

A fossil remora is described from the Oligocene shales in Glarus, Switzerland, under the name of *Opisthomyzon glaronensis*. It is characterized by the small disk posteriorly inserted. Its vertebræ are $10 + 13 = 24$ only. Dr. Storms gives the following account of this species:

"A careful comparison of the proportion of all the parts of the skeleton of the fossil *Echeneis* with those of the living forms, such as *Echeneis naucrates* or *Echeneis remora*, shows that the fossil differs nearly equally from both, and that it was a more normally shaped fish than either of these forms. The head was narrower and less flattened, the preoperculum wider, but its two jaws had nearly the same length. The ribs, as also the neural and hæmal spines, were longer, the tail more forked, and the soft dorsal fin much longer. In fact it was a more compressed type, probably a far better swimmer than

its living congeners, as might be expected if the smallness of the adhesive disk is taken into account."

Concerning the relations of the *Discocephali* Dr. Gill has the following pertinent remarks:

"The family of *Scomberoides* was constituted by Cuvier for certain forms of known organization, among which were fishes evidently related to *Caranx*, but which had free dorsal spines. Dr. Günther conceived the idea of disintegrating this family because, *inter alias*, the typical *Scomberoides* (family *Scombridæ*) have more than 24 vertebræ and others (family *Carangidæ*) had just 24. The assumption of Cuvier as to the relationship of *Elacate* (*Rachycentron*) was repeated, but inasmuch as it had 'more than 24 vertebræ' (it had $25 = 12 + 13$) it was severed from the free-spined *Carangidæ* and associated with the *Scombridæ*. *Elacate* has an elongated body, flattened head, and a longitudinal lateral band; therefore *Echeneis* was considered to be next allied to *Elacate* and to belong to the same family. The very numerous differences in structure between the two were entirely ignored, and the reference of the *Echeneis* to the *Scombridæ* is simply due to assumption piled on assumption. The collocation need not, therefore, longer detain us. The possession by *Echeneis* of the anterior oval cephalic disk in place of a spinous dorsal fin would alone necessitate the isolation of the genus as a peculiar family. But that difference is associated with almost innumerable other peculiarities of the skeleton and other parts, and in a logical system it must be removed far from the *Scombridæ*, and probably be endowed with subordinal distinction. In all essential respects it departs greatly from the type of structure manifested in the *Scombridæ* and rather approximates—but very distantly—the *Gobioidea* and *Blennioidea*. In those types we have in some a tendency to flattening of the head, of anterior development of the dorsal fin, a simple basis cranii, etc. Nevertheless there is no close affinity, nor even tendency to the extreme modification of the spinous dorsal exhibited by *Echeneis*. In view of all these facts *Echeneis*, with its subdivisions, may be regarded as constituting not only a family but a suborder. . . . Who can consistently object to the proposition to segregate the *Echeneididæ* as a suborder of teleocephalous fishes? Not those who consider that

the development of three or four inarticulate rays (or even less) in the front of the dorsal fin is sufficient to ordinarily differentiate a given form from another with only one or two such. Certainly the difference between the constituents of a disk and any rays or spines is much greater than the mere development or atrophy of articulations. Not those who consider that the manner of depression of spines, whether directly over the following, or to the right or left alternately, are of cardinal importance; for such differences, again, are manifestly of less morphological significance than the factors of a suctorial disk. Nevertheless there are doubtless many who will passively resist the proposition because of a conservative spirit, and who will vaguely refer to the development of the disk as being a 'teleological modification,' and as if it were not an actual fact and a development correlated with radical modifications of all parts of the skeleton at least. But whatever may be the closest relations of *Echeneis*, or the systematic value of its peculiarities, it is certain that it is not allied to *Elacate* any more than to hosts of scombroid, percoid, and kindred fishes, and that it differs *in toto* from it notwithstanding the claims that have been made otherwise. It is true that there is a striking resemblance, especially between the young—almost as great, for example, as that between the placental mouse and the marsupial *Antechinomys*—but the likeness is entirely superficial, and the scientific ichthyologist should be no more misled than would be the scientific therologist by the likeness of the marsupial and placental mammals."

Suborder Tæniosomi, the Ribbon-fishes.—The suborder *Tæniosomi* (*ταινία*, ribbon; *σῶμα*, body), or ribbon-fishes, is made up of strange inhabitants of the open seas, perhaps aberrant derivatives of the mackerel stock. The body is greatly elongate, much compressed, extremely fragile, covered with shining silvery skin. The ribbon-fishes live in the open sea, probably at no very great depth, but are almost never taken by collectors except when thrown on shore in storms or when attacked by other fishes and dragged above or below their depth. When found they are usually reported as sea-serpents, and although perfectly harmless, they are usually at once destroyed by their ignorant captors. The whole body is exceedingly fragile;

the bones are porous, thin, and light, containing scarcely any calcareous matter. In the *Tæniosomi* the ventral fins are thoracic, formed of one or a few soft rays. More remarkable is the character of the caudal fin, which is always distorted and usually not in line with the rest of the body. The teeth are small. The general structure is not very different from that of the cutlass-fishes, *Trichiuridæ*, and other degraded offshoots from the scombroid group. The species are few and, from the nature of things, very imperfectly known. Scarcely any specimens are perfectly preserved. When dried the body almost disappears, both flesh and bones being composed chiefly of water.

The Oarfishes: Regalecidæ.—The *Regalecidæ*, or oarfishes, have the caudal fin obsolete and the ventrals reduced to long filaments, thickened at the tip. The species reach a length of twenty or thirty feet, and from their great size, slender forms, and sinuous motion have been almost everywhere regarded as sea-serpents. The very long anterior spines of the dorsal fin are tipped with red, and the fish is often and not untruthfully described as a sea-serpent "having a horse's head with a flaming red mane."

The great oarfish, *Regalecus glesne* (see Fig. 237, Vol. I) was long known to the common people of Norway as king of the herrings, it being thought that to harm it would be to drive the herring to some other coast. The name "king of the herrings" went into science as *Regalecus*, from *rex*, king, and *halec*, herring. The Japanese fancy, which runs in a different line, calls the creature "Dugunonuatatori," which means the "cock of the palace under the sea."

The Atlantic oarfish is named *Regalecus glesne*, from the Norwegian farm of Glesnæs, where the first recorded specimen, described by Ascanius, was taken 130 years ago. Since then the species has been many times found on the shores of Great Britain and Norway, and once at Bemuda, but never in the United States.

In this species the body is half-transparent, almost jelly-like, light blue in color, with some darker cross-stripes, and the head has a long jaw and a high forehead, suggesting the head of a horse. The dorsal fin begins on the head, and the first

few spines are very long, each having a red tuft on the end. When the animal is alive these spines stand up like a red mane.

The creature is harmless, weak in muscle as well as feeble in mind. It lives in the deep seas, all over the world. After great storms it sometimes comes ashore. Perhaps this is because for some reason it has risen above its depth and so lost control of itself. When a deep-water fish rises to the surface the change of pressure greatly affects it. Reduction of pressure bursts its blood-vessels, its swim-bladder swells, if it has one, and turns its stomach inside out. If a deep-water fish gets above its depth it is lost, just as surely as a surface fish is when it gets sunk to the depth of half a mile.

Sometimes, again, these deep-sea fishes rush to the shore to escape from parasites, crustaceans that torture their soft flesh, or sharks that would tear it.

Numerous specimens have been found in the Pacific, and to these several names have been given, but the species are not at all clearly made out. The oldest name is that of *Regalecus russelli*, for the naturalist Patrick Russell, who took a specimen at Vizagapatam in 1788. I have seen two large examples of *Regalecus* in the museum at Tokio, and several young ones have recently been stranded on the Island of Santa Catalina in southern California. A specimen twenty-two feet long lately came ashore at Newport in Orange County, California. The story of its capture is thus told by Mr. Horatio J. Forgy, of Santa Ana, California:

"On the 22d of February, 1901, a Mexican Indian reported at Newport Beach that about one mile up the coast he had landed a sea-serpent, and as proof showed four tentacles and a strip of flesh about six feet long. A crowd went up to see it, and they said it was about twenty feet long and like a fish in some respects and like a snake in others. Mr. Remsberg and I, on the following day, went up to see it, and in a short time we gathered a crowd and with the assistance of Mr. Peabody prepared the fish and took the picture you have received.

"It measured twenty-one feet and some inches in length, and weighed about 500 or 600 pounds.

"The Indian, when he reported his discovery, said it was

alive and in the shallow water, and that he had landed it himself.

"This I very much doubt, but when it was first landed it was in a fine state of preservation and could have easily been shipped to you, but he had cut it to such an extent that shipment or preservation seemed out of the question when we first saw it.

"At the time it came ashore an unusual number of peculiar fishes and sharks were found. Among others, I found a small oarfish about three feet long in a bad state of preservation in a piece of kelp. One side of it was nearly torn off and the other side was decayed."

Mr. C. F. Holder gives this account of the capture of oarfishes in southern California:

"From a zoological point of view the island of Santa Catalina, which lies eighteen miles off the coast of Los Angeles County, southern California, is very interesting, many rare animals being found there. Every winter the dwellers of the island find numbers of argonaut-shells, and several living specimens have been secured, one for a time living in the aquarium which is maintained here for the benefit of students and the entertainment of visitors. A number of rare and interesting fishes wander inshore from time to time. Several years ago I found various Scopeloid fishes, which up to that time had been considered rare, and during the past few years I have seen one oarfish (*Regalecus russelli*) alive, while another was brought to me dead. From reports I judge that a number of these very rare fishes have been observed here. The first was of small size, not over two feet in length, and was discovered swimming in shallow water along the beach of Avalon Bay. I had an opportunity to observe the radiant creature before it died. Its 'topknot'—it can be compared to nothing else—was a vivid red or scarlet mass of seeming plumes—the dorsal fins, which merged into a long dorsal fin, extending to the tail. The color of the body was a brilliant silver sheen splashed with equally vivid black zebra-like stripes, which gave the fish a most striking appearance.

"The fish was a fragile and delicate creature, a very ghost of a fish, which swam along where the water gently lapped the sands with an undulatory motion, looking like one of its

names—the ribbon-fish. The fortunate finder of this specimen could not be persuaded to give it up or sell it, and it was its fate to be pasted upon a piece of board, dried in the sun as a 'curio,' where, as if in retaliation at the desecration of so rare a specimen, it soon disappeared.

"This apparently was the first oarfish ever seen in the United States, so at least Dr. G. Brown Goode wrote me at the time that it had not been reported. In 1899 another oarfish was brought to me, evidently having been washed in after a storm and found within a few yards of the former at Avalon. The discoverer of this specimen also refused to allow it to be properly preserved, or to donate or sell it to any one who would have sent it to some museum, but, believing it valuable as a 'curio,' also impaled it, the delicate creature evaporating under the strong heat of the semitropic sun.

"This, as stated, was the second fish discovered, and during the past winter (1900) a fine large specimen came in at Newport Beach, being reported by H. J. Forgy, of Santa Ana. The newspapers announced that a Mexican had found a young sea-serpent at Newport, and investigation showed that, as in hundreds of similar instances, the man had found a valuable prize without being aware of it. According to the account, the discoverer first saw the fish alive in the surf and hauled it ashore. Being ignorant of its value, he cut it up, bringing in a part of the scarlet fins and a slice of the flesh. This he showed to some men, and led the way to where lay the mutilated remains of one of the finest oar- or ribbon-fishes ever seen. The specimen was twenty-one feet in length, and its weight estimated at five hundred pounds. The finder had so mutilated it that the fish was ruined for almost any purpose. If he had packed it in salt, the specimen would have returned him the equivalent of several months' labor. Apparently the man had cut it up in wanton amusement.

"This recalls a similar incident. I was on one occasion excavating at San Clemente Island, and had remarked that it was a singular fact that all the fine stone ollas were broken. 'Nothing strange about that,' said a half-breed, one of the party. 'I used to herd sheep here, and we smashed mortars and ollas to pass away time.'"

FIG. 425.—Oarfish, *Regalecus russelli*, on the beach at Newport, Orange Co., Cal. (Photograph by C. P. Remsberg.)

The Dealfishes: Trachypteridæ.—The family of *Trachypteridæ* comprises the dealfishes, creatures of fantastic form and silvery coloration, smaller than the oarfishes and more common, but of similar habit.

Just as in Norway the fantastic oarfish was believed to be the king of the herrings and cherished as such, so among the Indians of Puget Sound another freak fish is held sacred as the king of the salmon. The people about Cape Flattery believe that if one does any harm to this fish the salmon will at once leave the shores. This fable led the naturalists who first discovered this fish to give it its name of *Trachypterus rex-salmonorum*.

In Europe a similar species (*Trachypterus atlanticus*) has long been known by the name of dealfish, or vogmar, neither of these names having any evident propriety.

The dealfish is one of the most singular of all the strange creatures of the sea. It reaches a length of three or four feet. Its body is thin as a knife and would be transparent were it not covered over with a shining white pigment which gives to the animal the luster of burnished silver. On this white surface is a large black blotch or two, but no other colors. The head is something like that of the oarfish, to which animal the dealfish bears a close relationship. Both have small teeth and neither could bite if it would, and neither wants to, for they are creatures of the most inoffensive sort. On the head of the dealfish, where the oarfish has its mane, is a long, streamer-like fin. At the end of the tail, instead of the ordinary caudal fin, is a long, slim fin which projects directly upwards at right angles to the direction of the back-bone. No other fish shows this strange peculiarity.

The dealfish swims in the open sea close to the surface of the water. It does not often come near shore, but it is occasionally blown on the beach by storms. *Trachypterus rex-salmonorum* has been recorded two or three times from Puget Sound and twice from California. The finest specimen known, the one from which our figure is taken, was secured off the Farallones in 1895 by a fisherman named W. C. Knox, and by him sent to Stanford University. The specimen is perfect in all its parts, a condition rare with these fragile creatures, and its picture gives a good idea of the mysterious king of the salmon.

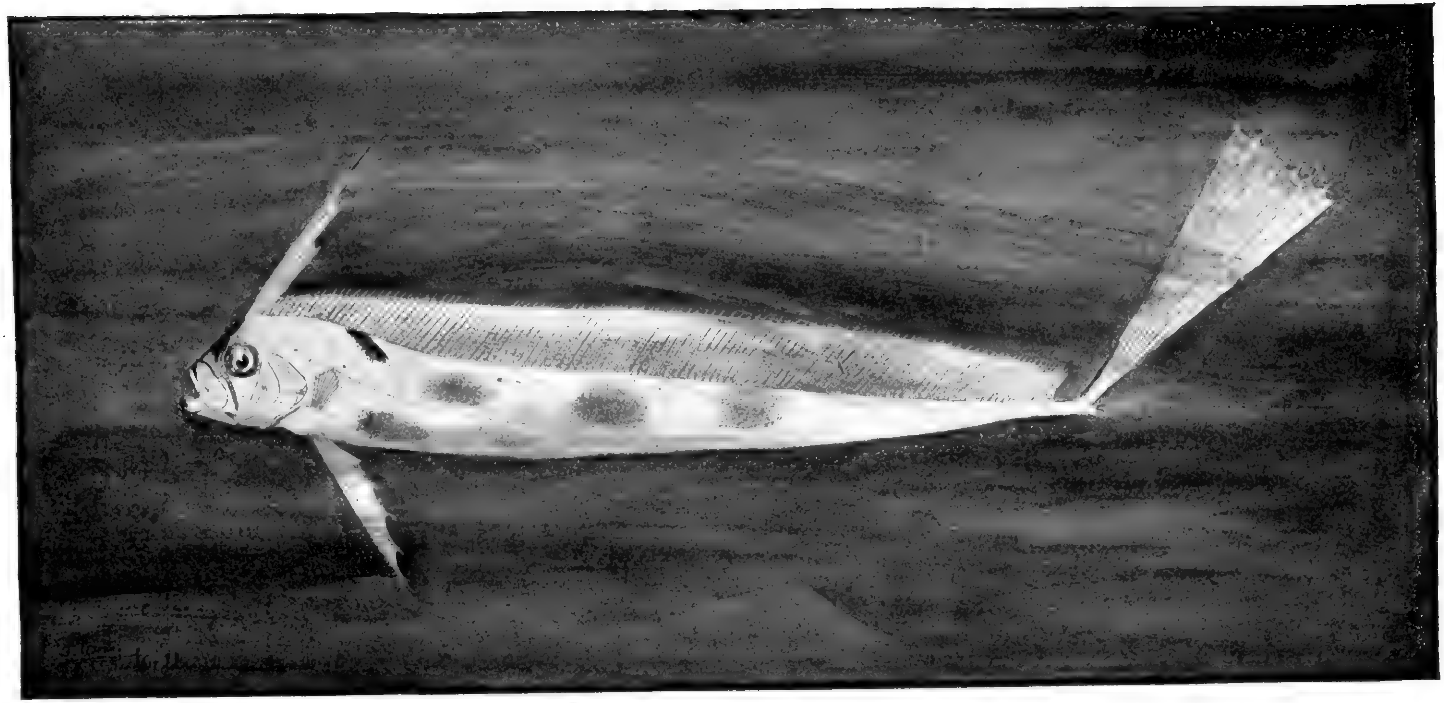


Fig. 426.—Dealfish, or King of the Salmon, *Trachypterus rex-salmonorum* Jordan & Gilbert. Family *Trachypteridæ*. (From a specimen taken off the Farallones.)

Four of these fishes have been obtained on the coast of Japan, and have been described and figured by the present writer in the annals of the Imperial University of Tokyo. These are different from the California species and are named *Trachypterus ishikawæ*, but they show the same bright silver color and the same streamers on the head and tail. Probably they, too, in Japan are kings of something or other, or perhaps silver swans from the submarine palace, for along such lines the Japanese fancy is more likely to run.

The young of the dealfish has the caudal symmetrical, and the dorsal spines and ventral rays produced in very long streamers.

According to Goode and Bean, the dealfishes are "true deep-sea fishes, which live at very great depths, and are only found when floating dead on the surface or washed ashore by the waves. Almost nothing is known of their habits except through Nilsson's observations in the far north. This naturalist, as well as Olafson, appears to have had the opportunity of observing them in life. They say that they approach the shore at flood-tide on sandy, shelving bottoms, and are often left by the retreating waves. Nilsson's opinion is that its habits resemble those of the flatfishes, and that they move with one side turned obliquely upward, the other toward the ground; and he says that they have been seen on the bottom in two or three fathoms of water, where the fishermen hook them up with the implements employed to raise dead seals, and that they are slow swimmers. This is not necessarily the case, however, for the removal of pressure and the rough treatment by which they were probably washed ashore would be demoralizing, to say the least. *Trichiurus*, a fish similar in form, is a very strong, swift swimmer, and so is *Regalecus*. Whether or not the habits of *Trachypterus arcticus*, on which these observations were made, are a safe guide in regard to the other forms is a matter of some doubt, but it is certain that they live far from the surface, except near the arctic circle, and that they only come ashore accidentally. They have never been taken by the deep-sea dredge or trawl-net, and indeed perfect specimens are very rare, the bodies being very soft and brittle, the bones and fin-rays exceedingly fragile. A considerable number of species have

been described, but in most instances each was based on one or two specimens. It is probable that future studies may be as fruitful as that of Emery, who, by means of a series of twenty-three specimens, succeeded in uniting at least three of the Mediterranean species which for half a century or more had been regarded as distinct. The common species of the eastern Atlantic, *Trachypterus atlanticus*, is not rare, one or more specimens, according to Günther, being secured along the coast of northern Europe after almost every severe gale. We desire to quote the recommendation of Dr. Günther, and to strongly urge upon any one who may be so fortunate as to secure one of these fishes that no attempt should be made to keep it entire, but that it should be cut into short lengths and preserved in the strongest spirits, each piece wrapped separately in muslin."

The family of *Stylephoridæ* is known from a single specimen of the species, *Stylephorus chordatus*, taken off Cuba in 1790. In this form the tail ends in a long, whip-like appendage, twice as long as the head.

No fossil dealfishes or oarfishes are known.

CHAPTER XXVII

SUBORDER HETEROSOMATA

THE **Flatfishes.**—Perhaps the most remarkable offshoot from the order of spiny-rayed fishes is the great group of flounders and soles, called by Bonaparte *Heterosomata* (ἕτερός, differing; σῶμα, body). The essential character of this group is found in the twisting of the anterior part of the cranium, an arrangement which brings both eyes on the same side of the head. This is accompanied by a great compression of the body, as a result of which the flounders swim horizontally or lie flat on the sand. On the side which is uppermost both eyes are placed, this side being colored, brown or gray or mottled. The lower side is usually plain white. In certain genera the right side is uppermost, in others the left. In a very few, confined to the coast of California, the eyes are on the right or left side indifferently.

The process of the twisting of the head has been already described (see p. 174, Vol. I). The very young have the body translucent and symmetrical, standing upright in the water. Soon the tendency to rest on the bottom sets in, the body leans to left or right, and the lower eye gradually traverses the front of the head to the other side. This movement is best seen in the species of *Platophrys*, in which the final arrangement of the eyes is a highly specialized one.

In some or all of the soles it is perhaps true that the eye turns over and pierces the cranium instead of passing across it. This opinion needs verification, and the process should be studied in detail in as many species as possible. The present writer has seen it in species of *Platophrys* only, the same genus in which it was carefully studied by Dr. Carlo F. Emery of Bologna. In the halibut, and in the more primitive flounders

generally, the process takes place at an earlier stage than in *Platophrys*.

Optic Nerves of Flounders.—In the Bulletin of the Museum of Comparative Zoology (Vol. XL, No. 5) Professor George H. Parker discusses the relations of the optic nerves in the group of flounders or flatfishes.

In the bony fishes the optic nerves pass to the optic lobes of the brain, the one passing to the lobes of the opposite side simply lying over the other, without intermingling of fibers, such as takes place in the higher vertebrates and in the more primitive fishes.

According to Parker's observations, in ordinary bony fishes the right nerve may be indifferently above or below the other. In 1000 specimens of ten common species, 486 have the left nerve uppermost and 514 the right nerve. In most individual species the numbers are practically equal. Thus, in the haddock, 48 have the left nerve uppermost and 52 the right nerve.

In the unsymmetrical teleosts or flounders, and soles, this condition no longer obtains. In those species of flounder with the eyes on the right side 236 individuals, representing sixteen species, had the left nerve uppermost in all cases.

Of flounders with the eyes on the left side, 131 individuals, representing nine species, all have the right nerve uppermost.

There are a few species of flounders in which reversed examples are so common that the species may be described as having the eyes on the right or left side indifferently. In all these species, however, whether dextral or sinistral, the relation of the nerves conforms to the type and is not influenced by the individual deviation. Thus the starry flounder (*Platichthys*) belongs to the dextral group. In 50 normal specimens, the eyes on the right have the left nerve dorsal, while the left nerve is also uppermost in 50 reversed examples with eyes on the left. In 15 examples of the California bastard halibut (*Paralichthys californicus*), normally sinistral, the right eye is always uppermost. It is uppermost in 11 reversed examples.

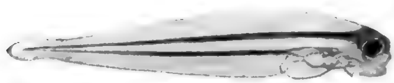


FIG. 427. — Young Flounder, just hatched, with symmetrical eyes. (After S. R. Williams.)

Among the soles this uniformity or monomorphism no

longer obtains. In 49 individuals of four species of dextral soles, the left nerve is uppermost in 24, the right nerve in 25. Among sinistral soles, or tonguefishes, in 18 individuals of two species, the left nerve is uppermost in 13, the right nerve in 5.

Professor Parker concludes from this evidence that soles are not degenerate flounders, but rather descended from primitive flounders which still retain the dimorphic condition as to the position of the optic nerves, a condition prevalent in all bony fishes except the flounders.

The lack of symmetry among the flounders lies, therefore, deeper than the matter of the migration of the eye. The asymmetry of the mouth is an independent trait, but, like the migration of the eye, is an adaptation to swimming on the side. Each of the various traits of asymmetry may appear independently of the others.

The development of the monomorphic arrangement in flounders Professor Parker thinks can be accounted for by the

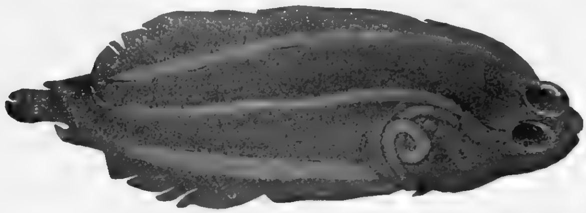


Fig. 428.—Larval Flounder, *Pseudopleuronectes americanus*. (After S. R. Williams.)

principle of natural selection. In a side-swimming fish the fixity of this trait has a mechanical advantage. The unmetamorphosed young of the flounder are not strictly symmetrical, for they possess the monomorphic position of the optic nerve. The reversed examples of various species of flounders (these, by the way, chiefly confined to the California fauna) afford "striking examples of discontinuous variation."

A very curious feature among the flounders is the possession in nine of the California-Alaskan species of an accessory half-lateral line. This is found in two different groups, while near relatives in other waters lack the character. One species in Japan has this trait, which is not found in any Atlantic species,

or in any other flounders outside the fauna of northern California, Oregon, and Alaska.

Ancestry of Flounders. — The ancestry of the flounders is wholly uncertain. Because, like the codfishes, the flounders lack all fin-spines, they have been placed by some authors after the *Anacanthini*, or codfishes, and a common descent has been assumed. Some writers declare that the flounder is only a codfish with distorted cranium.

A little study of the osteology of the flounder shows that this supposition is without foundation. The flounders have

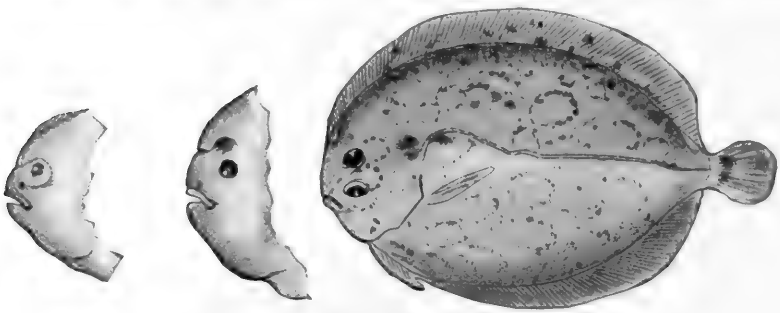


Fig. 429.

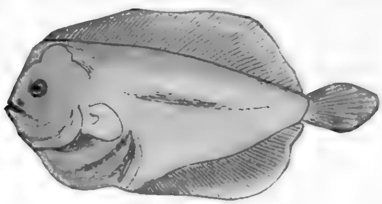


Fig. 430.

Figs. 429 and 430.—Larval stages of *Platophrys podas*, a flounder of the Mediterranean, showing the migration of the eye. (After Emery.)

thoracic ventrals, not jugular as in the cod. The tail is homocercal, ending in a large hypural plate, never isocercal, except in degraded soles, in which it is rather leptocercal. The shoulder-girdle, with its perforate hypercoracoid, has the normal perch-like form. The ventral fins have about six rays, as in the perch, although the first ray is never spinous. Pseudobranchiæ are developed, these structures being obsolete in the codfishes. The gills and pharyngeals are essentially as in the perch.

It is fairly certain that the *Heterosomata* have diverged from the early spiny-rayed forms, *Zeoidei*, *Berycoidei*, or *Scombroidei*

of the Jurassic or Cretaceous, and that their origin is prior to the development of the great perch stock.

If one were to guess at the nearest relationships of the group, it would be to regard them as allies of the deep-bodied mackerel-like forms, as the *Stromateidæ*, or perhaps with extinct Berycoid forms, as *Platycormus*, having the ventral fins wider than in the mackerel. Still more plausible is the recent suggestion of Dr. Boulenger that the extinct genus *Amphistium* resembles the primitive flounder. But there is little direct proof of such relation, and the resemblance of larval flounders to the ribbon-fishes may have equal significance. But the ribbon-fishes themselves may be degenerate Scombroids. In any case both ribbon-fishes and

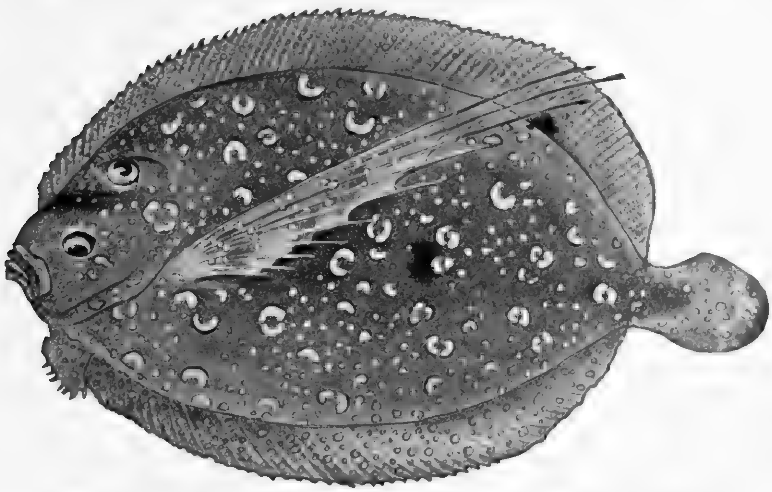


FIG. 431.—*Platophrys lunatus* (Linnæus), the Peacock Flounder. Family *Pleuronectidæ*. Cuba. (From nature by Mrs. H. C. Nash.)

flounders find their nearest living relatives among the *Berycoidei* or *Zeoidei*, and have no affinity whatever with the isocercal codfish or with other members of the group called *Anacanthini*.

The *Heterosomata* are found in all seas, always close to the bottom and swimming with a swift, undulatory motion. They are usually placed in a single family, but the degraded types known as soles may be regarded as forming a second family.

The Flounders: Pleuronectidæ.—In the flounders, or *Pleuronectidæ*, the membrane-bones of the head are distinct, the eyes large and well separated, the mouth not greatly contracted, and the jaws

always provided with teeth. Among the 500 species of flounders is found the greatest variation in size, ranging in weight from an ounce to 500 pounds. The species found in arctic regions are most degenerate and these have the largest number of vertebræ and of fin-rays. The halibut has 50 vertebræ (16 + 34), the craig-flounder 58, while in *Etropus* and other tropical forms the number is but 34 (10 + 24). The common flounders of intermediate geographical range (*Paralichthys dentatus*, etc.) show intermediate numbers as 40 (10 + 30). The apparent signifi-

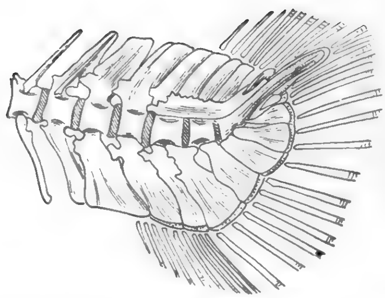


FIG. 432.

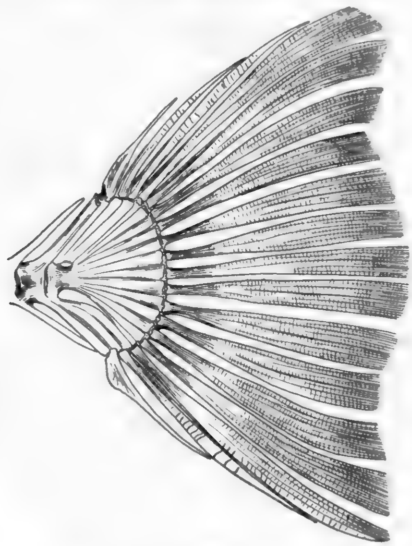


FIG. 433.

FIG. 432.—Heterocercal tail of young Trout, *Salmo fario* Linnæus. (After Parker & Haswell.)

FIG. 433.—Homocercal tail of a Flounder, *Paralichthys californicus*.

cance of this peculiar series of fact is given on page 212, Vol. I. It is, perhaps, related to the greater pressure of natural selection in the tropics, showing itself in the better differentiation of the bones and consequently smaller number of the vertebræ.

Fossil flounders are very few and give no clue as to the origin of the group. In the Eocene and Miocene are remains which have been referred to *Bothus* (*Rhombus*). *Bothus minimus* is the oldest species known, described by Agassiz from the Eocene of Monte Bolca. In the Miocene are numerous other species of *Bothus*, as also tubercles referable to *Scophthalmus*.

On the testimony of fossils alone the genus *Bothus*, or one

of its allies, would be the most primitive of the group. If it be so, the simpler structure of the halibut and its relatives is due to degeneration, which is probable, although their structure has the suggestion of primitive simplicity, especially in the greater approach to symmetry in the head and the symmetry in the insertion of the ventral fins.

Soles have been found in the later Tertiary rocks. *Solea kirchbergiana* of the Miocene is not very different from species

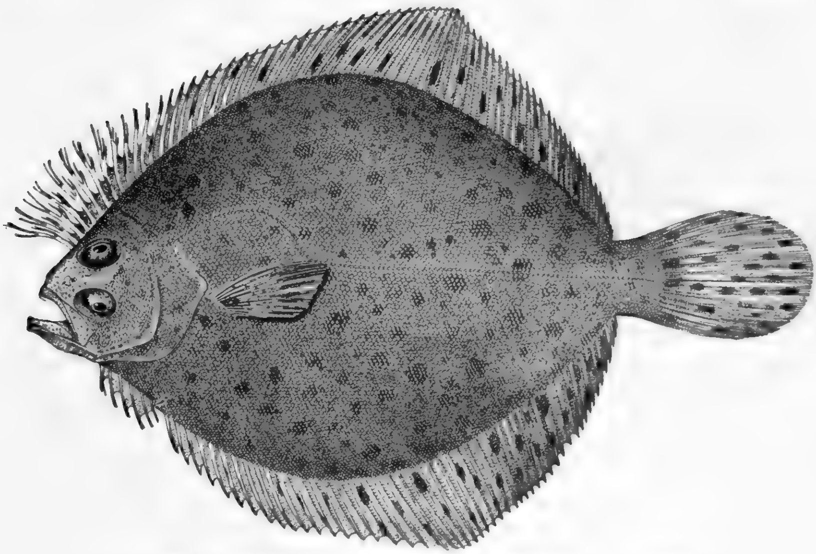


FIG. 434.—Window-pane, *Lophopsetta maculata*. Virginia.

now extant in southern Europe. No remains referable to allies of the halibut or plaice are found in Tertiary rocks, and these relatively simple types must be regarded as of recent origin.

The Turbot Tribe: Bothinæ.—The turbot tribe have the mouth large, the eyes and color on the left side, and the ventral fins unlike, that of the left side being extended along the ridge of the abdomen. The species are found in the warm seas only. They are deeper in body than the halibut and plaice, and some of them are the smallest of all flounders. It is probable that these approach most nearly of existing flounders to the original ancestors of the group.

Perhaps the most primitive genus is *Bothus*, species of which genus are found in Italian Miocene. The European

brill, *Bothus rhombus*, is a common fish of southern Europe, deep-bodied and covered with smooth scales.

Very similar but much smaller in size is the half translucent speckled flounder of our Atlantic coast (*Lophopsetta maculata*), popularly known as window-pane. This species is too small to have much value as food. Another species, similar to the brill in technical characters but very different in appearance, is the turbot, *Scophthalmus maximus*, of Europe. This large flounder has a very broad body, scaleless but covered with warty tubercles. It reaches a weight of seventy pounds and has a high value as a food-fish. There is but one species of turbot and it is found in Europe only, on sandy bottoms from

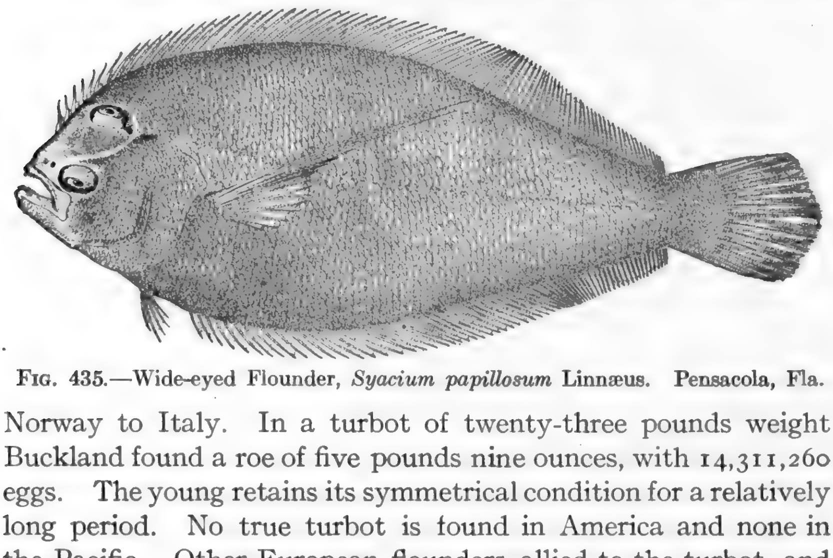


FIG. 435.—Wide-eyed Flounder, *Syacium papillosum* Linnæus. Pensacola, Fla.

Norway to Italy. In a turbot of twenty-three pounds weight Buckland found a roe of five pounds nine ounces, with 14,311,260 eggs. The young retains its symmetrical condition for a relatively long period. No true turbot is found in America and none in the Pacific. Other European flounders allied to the turbot and brill are *Zeugopterus punctatus;* the European whiff, *Lepidorhombus whiff-jagonis;* the topknot, *Phrynorhombus regius;* the lantern-flounder, *Arnoglossus laterna*, and the tongue-fish, *Eucitharus linguatula*, the last two of small size and feeble flesh.

In the wide-eyed or peacock flounders, *Platophrys podas* in Europe, *Platophrys lunatus*, etc., in America, *Platophrys mancus* in Polynesia, the eyes in the old males are very far apart, and the changes due to age and sex are greater than in any other genera. The species of this group are highly variegated and lie on the sand in the tropical seas. Numerous small

species allied to these abound in the West Indies, known in a general way as whiffs. The most widely distributed of these are *Citharichthys spilopterus* of the West Indies, *Citharichthys gilberti* and *Azevia panamensis* of Panama, *Orthopsetta sordida* of California, and especially the common small-mouthed *Etropus crossotus* found throughout tropical America. Numerous other genera and species of the turbot tribe are found on the coasts of tropical Asia and Africa, most of them of small size and weak structure.

Samaris cristatus of Asia is the type of another tribe of flounders and the peculiar hook-jawed *Oncopterus darwini* of Patagonia represents still another tribe.

The Halibut Tribe: Hippoglossinæ.—In the great halibut tribe the mouth is large and the ventral fins symmetrical. The arctic and subarctic species have the eyes and color on the

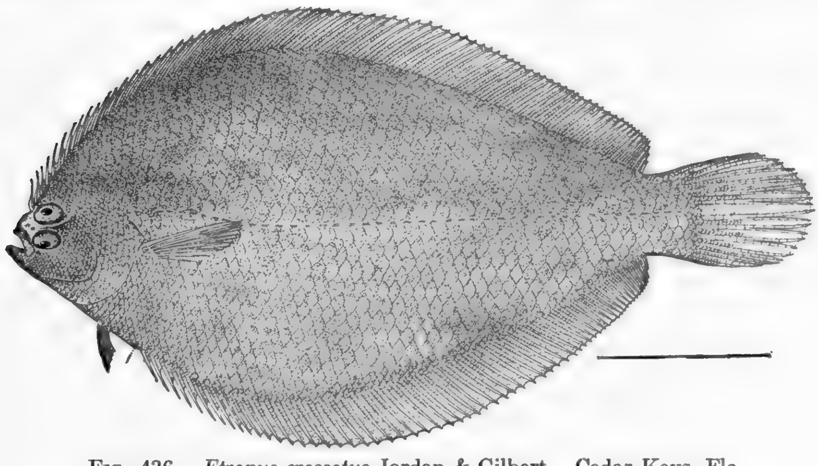


FIG. 436.—*Etropus crossotus* Jordan & Gilbert. Cedar Keys, Fla.

right. Those of the warmer regions (bastard halibut) have the eyes and color on the left. These grow progressively smaller in size to the southward, the mouth being smaller and more feebly armed in southern species.

The largest of the family, and the one commercially of far greatest importance, is the halibut (*Hippoglossus hippoglossus*). This species is found on both shores of both oceans, north of about the latitude of Paris, Boston, Cape Mendocino, and Matsushima Bay in Japan. Its preference is for offshore banks

of no great depth, and in very many localities it exists in great abundance, reaching a length of 6 to 8 feet and a weight of 600 pounds. It sometimes ranges well out to sea and enters deeper waters than the cod. The flesh is firm, white, and of good quality, although none of the flatfishes have much flavor, the muscles being mostly destitute of oil. Small halibut, called "chicken halibut," are highly esteemed.

Dr. Goode states that the "history of the halibut fishery has been a peculiar one. At the beginning of the present century these fishes were exceedingly abundant on George's Banks; since 1850 they have partially disappeared from this region, and the fishermen have since been following them to other banks, and since 1874 out into deeper and deeper water, and the fisheries are now carried on almost exclusively in the gullies between the offshore banks and on the outer edges of the banks, in water 100 to 350 fathoms in depth.

"The halibut with its large mouth is naturally a voracious fish, and probably would disdain few objects in the way of fresh meat it would come across. It is said, however, to feed more especially upon crabs and mollusks in addition to fish. These fish 'they waylay lying upon the bottom, invisible by reason of their flat bodies, colored to correspond to the general color of the sand or mud upon which they rest. When in pursuit of their prey they are active and often come quite to the surface, especially when in summer they follow the capelin to the shoal water near the land. They feed upon skates, cod, haddock, menhaden, mackerel, herring, lobsters, flounders, sculpins, grenadiers, turbot, Norway haddock, bank-clams, and anything else that is eatable and can be found in the same waters.' Frequently halibut may be seen chasing flatfish over the bottom of the water. About Cape Sable their favorite food seems to be haddock and cusk. A very singular mode of attacking a cod has been recorded by Captain Collins, an experienced fisherman and good observer. They often kill their prey by blows of the tail, a fact which is quite novel and interesting. He has described an instance which occurred on a voyage home from Sable Island in 1877: 'The man at the wheel sang out that he saw a halibut flapping its tail about a quarter of a mile off our starboard quarter. I looked through the spy-glass and his statement was

soon verified by the second appearance of the tail. We hove out a dory, and two men went with her, taking with them a pair of gaff-hooks. They soon returned, bringing not only the halibut, which was a fine one of about seventy pounds weight, but a small codfish which it had been trying to kill by striking it with its tail. The codfish was quite exhausted by the repeated blows and did not attempt to escape after its enemy had been captured. The halibut was so completely engaged in the pursuit of the codfish that it paid no attention to the dory and was easily captured.'

"The females become heavy with roe near the middle of the year, and about July and August are ready to spawn, although 'some fishermen say that they spawn at Christmas' or 'in the month of January, when they are on the shoals.' The roe of a large halibut which weighed 356 pounds weighed 44 pounds, and indeed the 'ovaries of a large fish are too heavy to be lifted by a man without considerable exertion, being often 2 feet or more in length.' A portion of the roe 'representing a fair average of the eggs, was weighed and found to contain 2185 eggs,' and the entire number would be 2,182,773."

Closely allied to the halibut are numerous smaller forms with more elongate body. The Greenland halibut, *Reinhardtius hippoglossoides*, and the closely related species in Japan, *Reinhardtius matsuuræ*, differ from the halibut most obviously in the straight lateral line. The arrow-toothed halibut, *Atheresthes stomias*, lives in deeper waters in the North Pacific. Its flesh is soft, the mouth very large, armed with arrow-shaped teeth. The head in this species is less distorted than in any of the others, the upper eye being on the edge of the disk in front of the dorsal fin. For this reason it has been supposed to be the most primitive of the living species, but these traits are doubtless elusive and a result of degeneration.

Eopsetta jordani is a smaller halibut-like fish, common on the coast of California, an excellent food-fish, with firm white flesh, sold in San Francisco restaurants under the very erroneous name of "English sole." Large numbers are dried by the Chinese for export to China. A similar species, *Hippoglossoides platessoides*, known as the "sand-dab," is common on both shores of the North Atlantic, and several related species are

found in the North Pacific. *Verasper variegatus* of Japan is notable for its bright coloration, the lower side being largely orange-red.

In the bastard halibuts, *Paralichthys*, the eyes and color are on the left side. These much resemble the true halibut, but are smaller and inferior as food, besides differing in details of structure. The Monterey halibut (*Paralichthys californicus*) is the largest of these, reaching a weight of sixty pounds. This species and one other from California (*Xystreurys liolepis*), normally left-sided, differ from all the other flounders in having

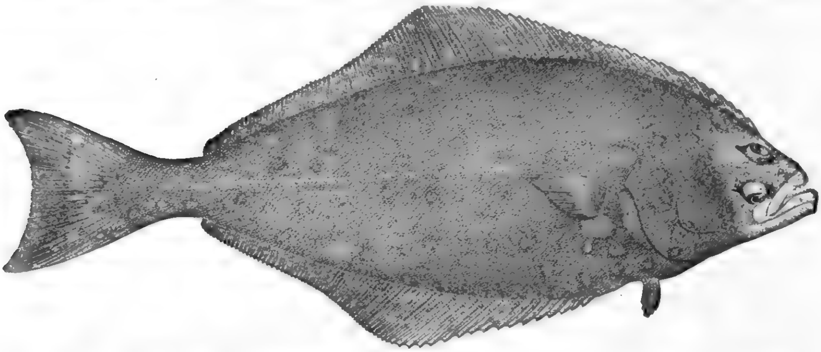


FIG. 437.—Halibut, *Hippoglossus hippoglossus* Linnæus. Marmot I., Alaska.

the eyes almost as often on the right side as on the left side, as usual or normal in their type. The summer flounder (*Paralichthys dentatus*) replaces the Monterey halibut on the Atlantic Coast, where it is a common food-fish. Farther south it gives way to the Southern flounder (*Paralichthys lethostigma*) and the Gulf flounder, *Paralichthys albigutta*. In Japan *Paralichthys olivaceus* is equally common, and in western Mexico *Paralichthys sinaloæ*. The four-spotted flounder of New England, *Paralichthys oblongus*, belongs to this group. Similar species constituting the genus *Pseudorhombus* abound in India and Japan.

The Plaice Tribe: Pleuronectinæ.—The plaice tribe pass gradually into the halibut tribe, from which they differ in the small mouth, in which the blunt teeth are mostly on the blind side. The eyes are on the right side, the vertebræ are numerous, and the species live only in the cold seas, none being found in the tropics. In most of the Pacific species the lateral line

has an accessory branch along the dorsal fin. The genus *Pleuronichthys*, or frog-flounders, has the teeth in bands. *Pleuronichthys cornutus* is common in Japan and three species, *Pleuronichthys cœnosus* being the most abundant, are found on the coast of California. Closely related to these is the diamond-flounder, *Hypsopsetta guttulata* of California. *Parophrys vetulus* is a small flounder of California, so abundant as to have considerable economic value. *Lepidopsetta bilineata*, larger and rougher, is almost equally common. It is similar to the mud-dab (*Limanda limanda*) of northern Europe and the rusty-dab (*Limanda ferruginea*) of New England.

The plaice, *Pleuronectes platessa*, is the best known of the European species of this type, being common in most parts of Europe and valued as food. Closely related to the plaice is a second species of southern Europe also of small size, *Flesus*

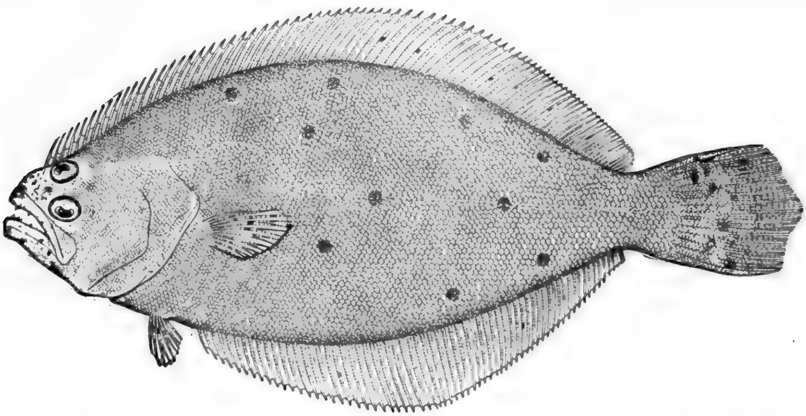


FIG. 438.—Wide mouthed Flounder, *Paralichthys dentatus* (L.). St. George I., Md.

flesus, to which the name flounder is in England especially applied. The common winter flounder of New England, *Pseudopleuronectes americanus*, is also very much like the plaice, but with more uniform scales. It is an important food-fish, the most abundant of the family about Cape Cod. The eel-back flounder, *Liopsetta putnami*, also of New England, is frequently seen in the markets. The males of this species have scattered rough scales, while the females are smooth. The great starry flounder of Alaska, *Platichthys stellatus*, is the largest of the small-mouthed flounders and in its region the most

abundant. On the Pacific coast from Monterey to Alaska and across to northern Japan it constitutes half the catch of flounders. The body is covered with rough scattered scales, the fins are barred with black. It reaches a weight of twenty pounds. Living in shallow waters, it ascends all the larger rivers.

An allied species in Japan is *Kareius bicoloratus*, with scattered scales. *Clidoderma asperrimum*, also of northern Japan, has the body covered with series of warts.

In deeper water are found the elongate forms known as smear-dab and flukes. The smear-dab of Europe (*Micro-*

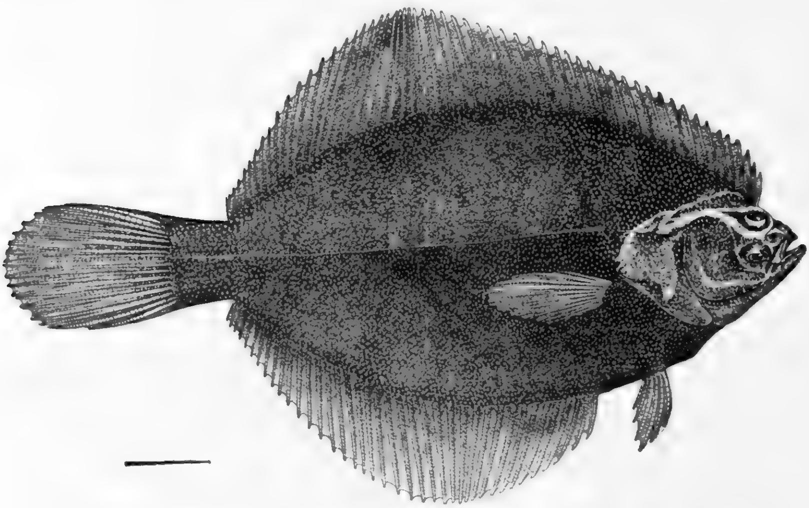


FIG. 439.—Eel-back Flounder, *Liopsetta putnami* (Gill). Salem, Mass.

stomus kitt) is rather common in deep water. Its skin is very slimy, but the flesh is excellent. The same is true of the slippery sole, *Microstomus pacificus*, of California and Alaska, and of other species found in Japan. *Glyptocephalus cynoglossus*, the craig-fluke, or pole-flounder, of the North Atlantic, is taken in great numbers in rather deep water on both coasts. Its flesh is much like that of the sole. A similar species (*Glyptocephalus zachirus*) with a very long pectoral on the right scale is found in California, and *Microstomus kitaharæ* in Japan.

The Soles: Soleidæ.—The soles (*Soleidæ*) are degraded flounders, the typical forms bearing a close relation to the plaice tribe, from which they may be derived. There are three very different groups or tribes of soles, and some writers have thought that these are independently derived from different groups of flounders. This fact has been urged as an argument against the recognition of the *Soleidæ* as a family separate from the flounders. If clearly proved, the soles should either be joined with the flounders in one family or else they should be divided into two or three, according to their supposed origin.

The soles as a whole differ from the flounders in having the bones of the head obscurely outlined, their edges covered by scales. The gill-openings are much reduced, the eyes small and close together, the ventral fins often much reduced, and sometimes the pectoral or caudal also. The mouth is very small, much twisted, and with few teeth.

The species of sole, about 150 in number, abound on sandy

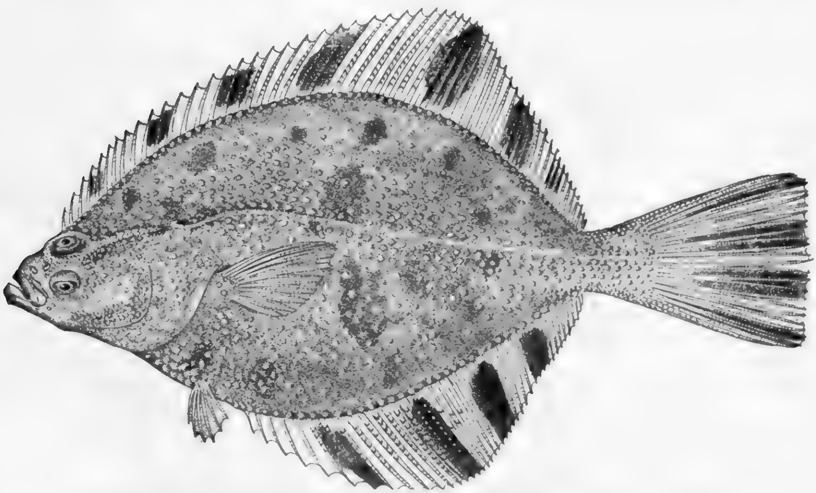


FIG. 440.—Starry Flounder, *Platichthys stellatus* (Pallas). Alaska.

bottoms in the warm seas along the continents, very few being found about the Oceanic Islands. The three subfamilies, or tribes, may be designated as broad soles, true soles, and tonguefishes.

The Broad Soles: Achirinæ.—The American soles (*Achirinæ*), or broad soles, resemble the smaller members of the turbot tribe

of flounders, having the ventral fin of the eyed side extended along the ridge of the abdomen. The eyes and color are, however, on the right side. The eyes are separated by a narrow interorbital ridge. In most of these forms the body is broad and covered with rough scales. The species are mostly less than six inches long, and nearly all are confined to the warmer parts of America, many of them ascending the rivers. A very few (*Aseraggodes*, *Pardachirus*) are found in Japan and China. Some are scaleless and some have but a single small gill-opening on the blind side. The principal genus is *Achirus*. *Achirus fasciatus*, the common American sole, or hog-choker, is abundant from Boston to Galveston. *Achirus lineatus* and other species are found in the West Indies and on the west coast of Mexico. Almost all the species of *Achirus* are banded with black and the pectorals are very small or wanting altogether. All these species are practically useless as food from their very small size.

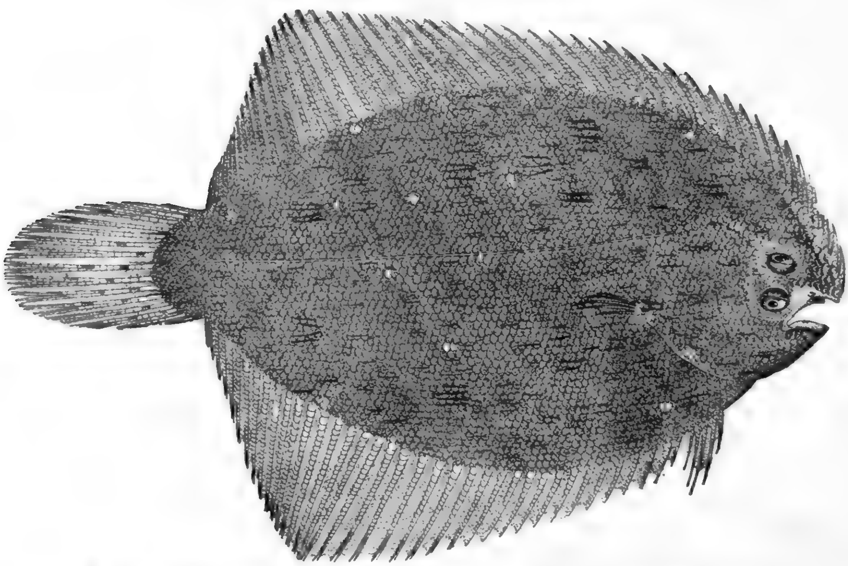


FIG. 441.—Hog-choker Sole, *Achirus lineatus* (L.). Potomac River.

The European Soles (Soleinæ).—The European soles are more elongate in form, with the ventral fins narrow and not extended along the ridge of the abdomen. The eyes are on the right side with no bony ridge between them. No species of this type is

certainly known from American waters, although numerous in Europe and Asia. The species have much in common with the plaice tribe of flounders and may be derived from the same stock. One species, as above noted, is found in the Miocene.

The common sole of Europe, *Solea solea*, is one of the best of food-fishes, reaching a length, according to Dr. Gill, of twenty-six inches and a weight of nine pounds. As usually seen in the markets it rarely exceeds a pound. It is found from Norway to Italy, and when properly cooked is very tender and delicate, superior to any of the flounders. According to Dr. Francis Day, it appears to prefer sandy or gravelly shores, but is rather uncertain in its migrations, for, although mostly appearing at certain spots almost at a given time, and usually decreasing in numbers by degrees, in other seasons they disappear at once, as suddenly as they arrive. Along the British seacoast they retire to the deep as frosts set in, revisiting the shallows about May if the weather is warm, their migrations being influenced by temperature. The food of the sole is to a considerable extent molluscous, but it is also said to eat the eggs and fry of other fishes and sea-urchins

The spawning season is late in the year and during the spring months. The ova are in moderate number; a sole of one pound weight has, according to Buckland, about 134,000 eggs. The newly hatched, according to Dr. Day, do not appear to be commonly found so far out at sea as some other species. They enter into shallow water at the edge of the tide and are very numerous in favorable localities.

As is well known, the sole is one of the most esteemed of European fishes. In the words of Dr. Day, "the flesh of this fish is white, firm, and of excellent flavor, those from the deepest waters being generally preferred. Those on the west coast and to the south are larger, as a rule, than those towards the north of the British islands. In addition to its use as food, it is available for another purpose. The skin is used for fining coffee, being a good substitute for isinglass, and also as a material for artificial baits.

"The markets are generally supplied by the trawl. The principal English trawling-ground lies from Dover to Devonshire. They may be taken by spillers, but are not commonly captured

with hooks; it is suggested that one reason may be that spillers are mostly used by day, whereas the sole is a night feeder. They are sometimes angled for with the hook, baited with crabs, worms, or mollusks; the most favorable time for fishing is at night, after a blow, when the water is thick, while a land breeze answers better than a sea breeze."

Several smaller species of sole are found in Europe. In Japan *Zebrias zebra*, black-banded, and *Usinosita japonica*, known as *Usinóshita*, or cow's tongue, are common. Farther south are numerous species of *Synaptura* and other genera peculiar to the Indian and Australian regions.

The Tongue-fishes: Cynoglossinæ.—The tongue-fishes are soles having the eyes on the left side not separated by a bony ridge, the two being very small and apparently in the same socket. The body is lanceolate, covered usually with rough scales, and as often with two or three lateral lines as with one. The species are mostly Asiatic. *Cynoglossus robustus* and other species are found in Japan, and in India are many others belonging to *Cynoglossus* and related genera. The larger species are valued as food. The single European species *Symphurus nigrescens*, common in the Mediterranean, is too small to have any value. *Symphurus plagiusa*, the tongue-fish of our coast, is

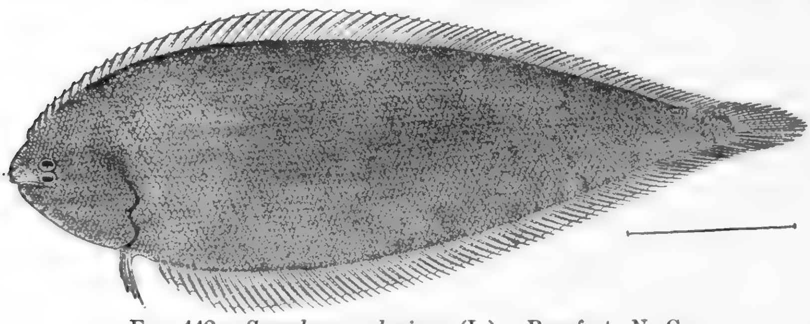


Fig. 442.—*Symphurus plagiusa* (L.). Beaufort, N. C.

common on our sandy shores from Cape Hatteras southward. *Symphurus plagusia*, scarcely different, replaces it in the West Indies. *Symphurus atricandus* is found in San Diego Bay, and numerous other species of no economic importance find their place farther south.

CHAPTER XXVIII

SUBORDER JUGULARES

THE Jugular-fishes.—In all the families of spiny-rayed fishes, as ranged in order in the present work, from the *Berycidæ* to the *Soleidæ*, the ventrals are thoracic in position, the pelvis, if present, being joined to the shoulder-girdle behind the symphysis of the clavicles so that the ventral fin falls below or behind the pectoral fin. To this arrangement the families of *Bembradidæ* and *Pinguipedidæ* offer perhaps the only exceptions.

In all the families which precede the *Berycidæ* in the linear series adopted in this work, the ventral fins when present are abdominal, the pelvis lying behind the clavicles and free from them as in the sharks, the reptiles, and all higher vertebrates.

In all the families remaining for discussion, the ventrals are brought still farther forward to a point distinctly before the pectorals. This position is called jugular (Lat. *jugulum*, throat).

The fishes with jugular ventrals we here divide into six groups, orders, and suborders: *Jugulares*, *Haplodoci*, *Xenopterygii*, *Anacanthini*, *Opisthomi*, and *Pediculati*. The last two groups, and perhaps the *Anacanthini* also, may well be considered as distinct orders, being more aberrant than the others.

For the most primitive and at the same time most obscurely defined of these groups we may retain the term applied by Linnæus to all of them, the name *Jugulares*. This group includes those jugular-fishes in which the position of the gills, the structure of the skull, and the form of the tail are essentially as in ordinary fishes. It is an extremely diversified and perhaps unnatural group, some of its members resembling *Opisthognathidæ* and *Malacanthidæ*, others suggesting the mailed-cheek

fishes, and still others more degenerate. The fishes having the fins thus placed were long ago set apart by Linnæus, under the name of "Jugulares," *Callionymus* being the genus first placed by him in this group. Besides their anterior insertion, the ventrals in the *Jugulares* are more or less reduced in size, the rays being usually but not always less than I, 5 in number and more often reduced to one or two, or even wholly lost.

In general, the jugular fishes are degenerate as compared with the perch-like forms, but in certain regards they are often highly specialized. The groups showing this character are probably related one to another, but in some cases this fact is not clearly shown. In most of the jugular-fishes the shoulder-girdle shows some change or distortion. The usual foramen in the hypercoracoid is often wanting or relegated to the interspace between the coracoids, and the arrangement of the actinosts often deviates from that seen in the perciform fishes.

The Weevers: Trachinidæ.—Of the various families the group of weevers, *Trachinidæ*, most approaches the type of ordinary fishes. In the words of Dr. Gill, these fishes are known by "an elongated body attenuated backward from the head, compressed, oblong head, with the snout very short, a deeply cleft, oblique mouth, and a long spine projecting backward from each operculum and strengthened by extension on the surface of the operculum, as a keel. The dorsal fins are distinct, the first composed of strong, pungent spines radiating from a short base and about six or seven in number. The second dorsal and anal are very long. The pectorals have the lower rays unbranched, and the ventrals are in advance of the pectorals, and have each a spine and five rays. The species of this family are mostly found along the European and western African coast; but singularly enough a species closely related to the Old World form is found on the coast of Chile. None have been obtained from the intermediate regions or from the American coast. Two species are found in England, and are known under the name of the greater weever (*Trachinus draco*), about twelve inches long, and the lesser weever (*Trachinus vipera*), about six inches long. They are perhaps the most dreaded of the smaller English fishes. The formid-

able opercular spines are weapons of defense, and when seized by the fisherman the fish is apt to throw its head in the direction of the hand and lance a spine into it. The pungent dorsal spines are also defensive. Although without a poison gland, such as some fishes distantly related have at the base of the spines, they cause very severe wounds, and death may occur from tetanus. They are therefore divested of both opercular and dorsal spines before being exposed for sale. The various popular names which the weevers enjoy, in addition to their general designation, mostly refer to the armature of the spines, or are the result of the armature; such are adder-fish, sting-fish, and sting-bull."

No species of *Trachinidæ* is known from North America or from Asia. In these fishes, as Dr. Boulenger has lately shown, the hypercoracoid is without foramen, the usual perforation lying between this bone and the hypercoracoid. A similar condition exists in the *Anacanthini*, or codfishes, but it seems to have been developed independently in the two groups. In the relatives of the *Trachinidæ* the position of this foramen changes gradually, moving by degrees from its usual place to the lower margin of the hypercoracoid. Species referred to *Trachinus* are recorded from the Miocene as well as *Trachinus*.

The extinct group of *Callipterygidæ* found in the Eocene of Monte Bolca seems allied to the *Trachinidæ*. It has the dorsal fin continuous, the spines small, the soft rays high; the scales are very small or wanting. *Callipteryx speciosus* and *C. recticandus* are the known species.

The Nototheniidæ.—In the family of *Nototheniidæ* the foramen is also wanting or confluent with the suture between the coracoids. To this family belong many species of the Antarctic region. These are elongate fishes with ctenoid scales and a general resemblance to small *Hexagrammidæ*. In most of the genera there is more than one lateral line. These species are the antipodes of the *Cottidæ* and *Hexagrammidæ;* although lacking the bony stay of the latter, they show several analogical resemblances and have very similar habits.

The *Harpagiferidæ*, naked, with the opercle armed with spines, and resemble sculpins even more closely than do the *Nothothenidæ*. *Harpagifer* is found in Antarctic seas, and the three species of

Draconetta in the deeper waters of the North Atlantic and Pacific. These little fishes resemble *Callionymus*, but the opercle, instead of the preopercle, bears spines. The *Bovichthyidæ* of New Zealand are also sculpin-like and perhaps belong to the same family. Dr. Boulenger places all these Antarctic forms with the foramen outside the hypercoracoid in one family, *Nototheniidæ*. Several deep-sea fishes of this type have been lately described by Dr. Louis Dollo and others from the Patagonian region. One of these forms, *Macrias amissus*, lately named by Gill and Townsend, is five feet long, perhaps the largest deep-sea fish known. The family of *Percophidæ*, from Chile, is also closely

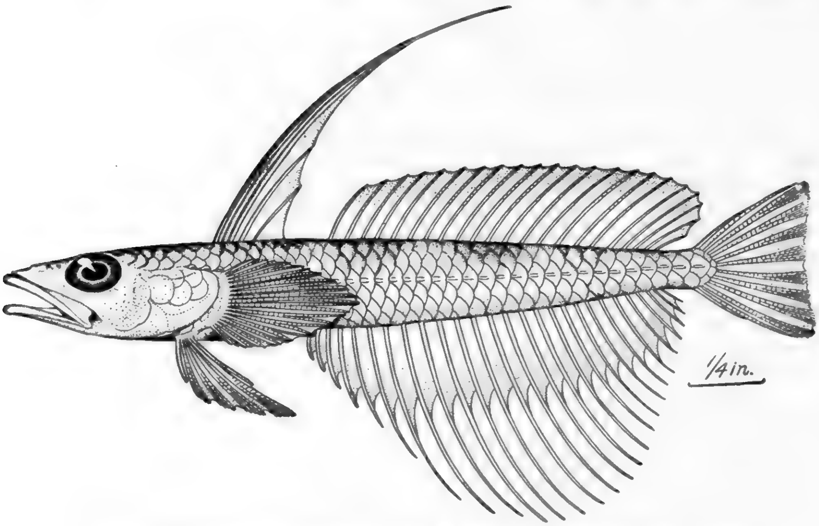


FIG. 443.—*Pteropsaron evolans* Jordan & Snyder. Sagami Bay, Japan.

allied to these forms, the single species differing in slight respects of osteology.

Closely related to the family of *Nototheniidæ* and perhaps scarcely distinct from it is the small family of *Pteropsaridæ*, which differs in having but one lateral line and the foramen just above the lower edge of the hypercoracoid. The numerous species inhabit the middle Pacific, and are prettily colored fishes, looking like gobies. *Pteropsaron* is a Japanese genus, with high dorsal and anal fins; *Parapercis* is more widely diffused. *Osurus schauinslandi* is one of the neatest of the small fishes of Hawaii. Several species of *Parapercis* and *Neopercis* occur in

Japan and numerous others in the waters of Polynesia. *Pseudeleginus majori* of the Italian Miocene must belong near *Parapercis.*

The *Bathymasteridæ*, or ronquils, are perhaps allied to the *Nototheniidæ;* they resemble the *Opisthognathidæ*, but the jaws are shorter and they have a large number of vertebræ as befits their northern distribution. *Ronquilus jordani* is found in Puget Sound and *Bathymaster signatus* in Alaska. The ventral rays are I, 5, and the many-rayed dorsal has a few slender spines in front.

The Leptoscopidæ.—The *Leptoscopidæ* of New Zealand resemble the weevers and star-gazers, but the head is unarmed, covered by thin skin.

The Star-gazers: Uranoscopidæ.—The *Uranoscopidæ*, or star-

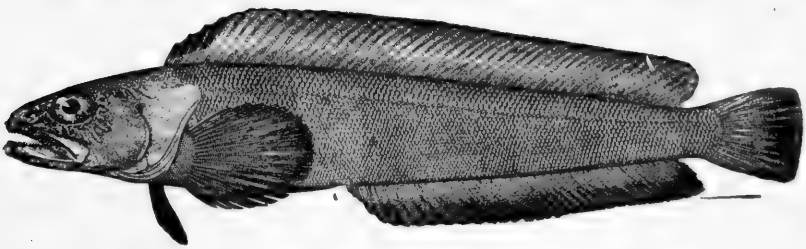


FIG. 444.—*Bathymaster signatus* Cope. Shumagin Is., Alaska.

gazers, have the head cuboid, mostly bony above, the mouth almost vertical, the lips usually fringed, and the eyes on the flat upper surface of the head. The spinous dorsal is short and may be wanting. The hypercoracoid has a foramen, and the body is naked or covered with small scales. The appearance is eccentric, like that of some of the *Scorpænidæ*, but the anatomy differs in several ways from that of the mailed-cheek fishes.

The species inhabit warm seas, and the larger ones are food-fishes of some importance. One species, *Uranoscopus scaber*, abounds in the Mediterranean. *Uranoscopus japonicus* and other species are found in Japan. *Astroscopus y-græcum* is the commonest species on our Atlantic coast. The bare spaces on the top of the head in this species yield vigorous electric shocks. Another American species is *Astroscopus guttatus*. In Japan and the East Indies the forms are more numerous and varied. *Ichthyscopus lebeck*, with a single dorsal, is a fantastic

inhabitant of the seas of Japan, and *Anema monopterygium* in New Zealand.

Uranoscopus peruzzii, an extinct star-gazer, has been described from the Pliocene of Tuscany.

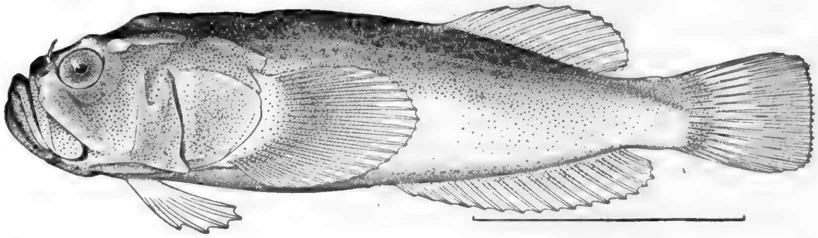


FIG. 445.—A Star-gazer *Ariscopus iburius* Jordan & Snyder. Iburi, Japan.

The Dragonets: Callionymidæ.—Remotely allied to the *Uranoscopidæ* is the interesting family of dragonets, or *Callionymidæ*. These are small scaleless fishes with flat heads, the preopercle armed with a strong spine, the body bearing a general resemblance to the smaller and smoother *Cottidæ*. The gill-openings are very small, the ventral fins wide apart. The colors are highly variegated, the fins are high, often filamentous, and the sexes differ much in coloration and in the development of the fins. The species are especially numerous on the shores of Japan, where *Callionymus valenciennesi*, *Callionymus beniteguri*, and *Calliurichthys japonicus* are food-fishes of some slight importance. Others are found in the East Indies, and several large and handsome forms are taken in the Mediterranean. *Callionymus draco*, the dragonet, or "sculpin," reaches the coast of England. In America but three species have been taken. These are dredged in deep water in the East Indies. In other parts of the world these fantastic little creatures are shore-fishes, creeping about in the shallow bays. Species of *Synchiropus*, colored like the coral sands, abound in the Polynesian coral reefs.

A fossil species of *Callionymus* (*C. macrocephalus*) are found in the Miocene of Croatia.

The family of *Rhyacichthyidæ* is a small group of Asiatic fishes allied to the *Callionymidæ*, but less elongate and differing in minor details. They are found not in the sea, but in mountain streams. *Rhyacichthys* (formerly called by the preoccupied name *Platyptera*) is the principal genus.

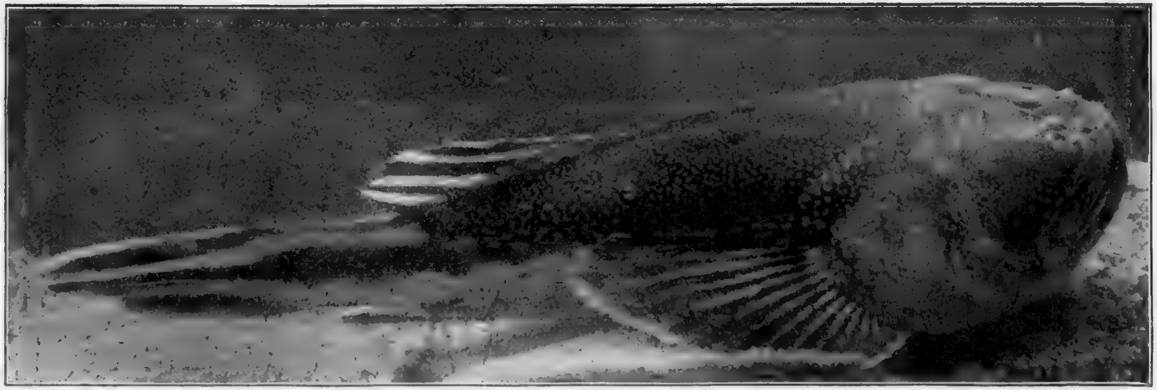


Fig. 446.—Star-gazer, *Astroscopus guttatus* Abbott. (From life by Dr. R. W. Shufeldt.)

The *Trichonotidæ*, with wide gill-openings and cycloid scales, are also related to the *Callionymidæ*. The species are few, small, and confined to the Indian and Australian seas. Another small family closely related to this is the group of *Hemerocœtidæ* of the same region.

The Dactyloscopidæ.—In this and the preceding families of jugular fishes the ventral rays remain 1, 5, as in the typical thoracic forms. In most of the families yet to be described the number is I, 3, a character which separates the little fishes of the family of *Dactyloscopidæ* from the *Uranoscopidæ* and *Leptoscopidæ*. *Dactyloscopus tridigitatus* is a small fish of the coral sands of Cuba. The other species of this family are found mostly in the West Indies and on the west coast of Mexico. Several genera, *Myxodagnus*, *Gillellus*, *Dactylagnus*, etc., are recognized. In the structure of the shoulder-girdle these species diverge from the star-gazers, approaching the blennies, and their position is intermediate between *Trachinidæ* and *Blenniidæ*.

CHAPTER XXIX

THE BLENNIES: BLENNIIDÆ

THE great family of blennies, *Blenniidæ*, contains a vast number of species with elongate body, numerous dorsal spines, without suborbital stay or sucking-disk, and the ventrals jugular, where present, and of one spine and less than five soft rays. Most of them are of small size, living about rocks on the sea-shores of all regions. In general they are active fishes, of handsome but dark coloration, and in the different parts of the group is found great variety of structure. The tropical forms differ from those of arctic regions in the much shorter bodies and fewer vertebræ. These forms are most like ordinary fishes in appearance and structure and are doubtless the most primitive. Of the five hundred known species of

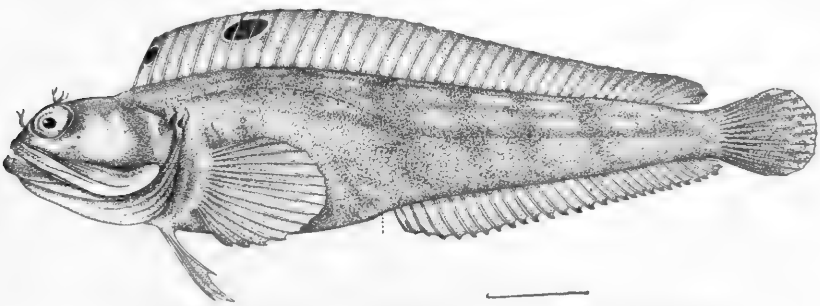


FIG. 447.—Sarcastic Blenny, *Neoclinus satiricus* Girard. Monterey.

blennies, we can note only a few of the most prominent. To *Clinus* and related genera belong many species of the warm seas, scaly and ovoviviparous, at least for the most part. The largest of these is the great kelpfish of the coast of California, *Heterostichus rostratus*, a food-fish of importance, reaching the length of two feet. Others of this type scarcely exceed two inches. *Neoclinus satiricus*, also of California, is remarkable

for the great length of the upper jaw, which is formed as in *Opisthognathus*. Its membranes are brightly colored, being edged with bright yellow. *Gibbonsia elegans* is the pretty "señorita" of the coralline-lined rock-pools of California. *Lepisoma nuchipinne*, with a fringe of filaments at the nape, is very

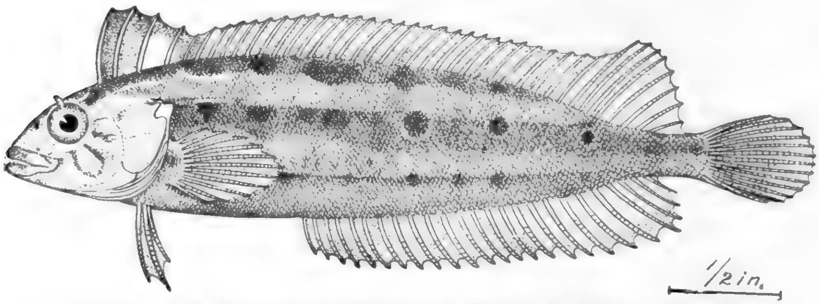


FIG. 448.—Kelp Blenny, *Gibbonsia evides* Jordan & Gilbert. San Diego.

abundant in rock-pools of the West Indies. The species of *Auchenopterus* abound in the rock-pools of tropical America. These are very small neatly colored fishes with but one soft ray in the long dorsal fin. Species of *Tripterygion*, *Myxodes*, *Cristiceps*, and other genera abound in the South Pacific.

In *Blennius* and its relatives the body is scaleless and the slender teeth are arranged like the teeth of a comb. In most

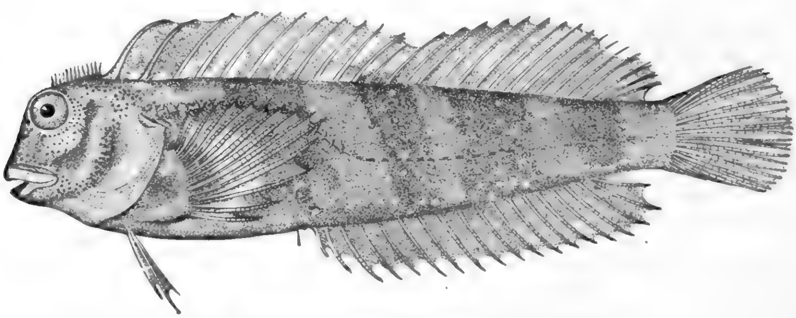


FIG. 449.—*Blennius cristatus* L. Florida.

species long, fang-like posterior canines are developed in the jaws. *Blennius* is represented in Europe by many species, *Blennius galerita*, *ocellaris*, and *basiliscus* being among the most common. Certain species inhabit Italian lakes, having assumed a fresh-water habit. The numerous American species mostly

belong to other related genera, *Chasmodes bosquianus* being most common. *Blennius yatabei* abounds in Japan. In *Petroscirtes* and its allies the gill-openings are much restricted. The

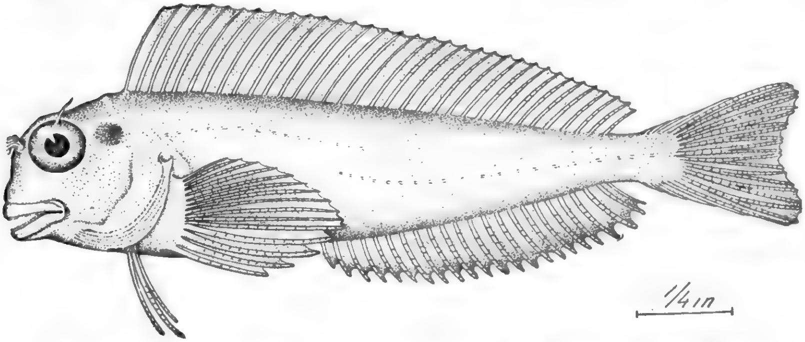


FIG. 450.—Rock-skipper, *Alticus atlanticus*. San Cristobal, Lower Cal.

FIG. 451.—Lizard-skipper, *Alticus saliens* (Forster). A blenny which lies out of water on lava rocks, leaping from one to another with great agility. From nature; specimen from Point Distress, Tutuila Island, Samoa. (About one-half size.)

species are mainly Asiatic and Polynesian and are very prettily colored. *Petroscirtes elegans* and *P. trossulus* adorn the Japanese

rock-pools and others, often deep blue in color, abound in the coral reefs of Polynesia.

The rock-skippers (*Salarias*, *Alticus*, etc.) are herbivorous, with serrated teeth set loosely in the jaws. These live in the rock-pools of the tropics and leap from rock to rock when disturbed with the agility of lizards. They are dusky or gray in color with handsome markings. One of them, *Erpichthys* or *Alticus saliens* in Samoa, lives about lava rocks between tide-

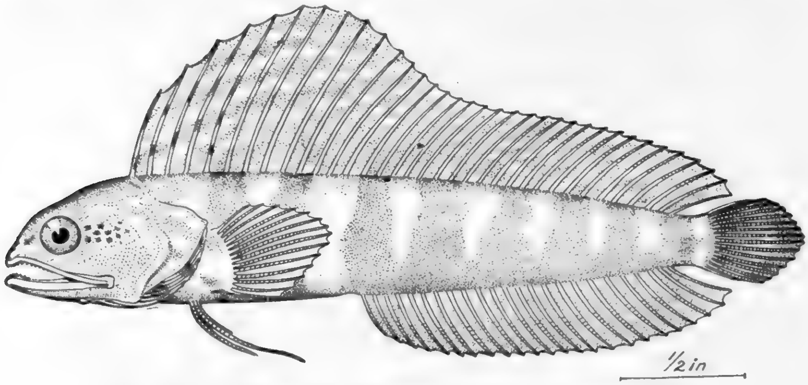


FIG. 452.—*Emblemaria atlantica* Jordan. Pensacola, Fla.

marks, and at low tide remains on the rocks, over which it runs with the greatest ease and with much speed, its movements being precisely like those of *Periophthalmus*. As in the species of the latter genus, otherwise wholly different, this *Alticus* has short ventral fins padded with muscle.

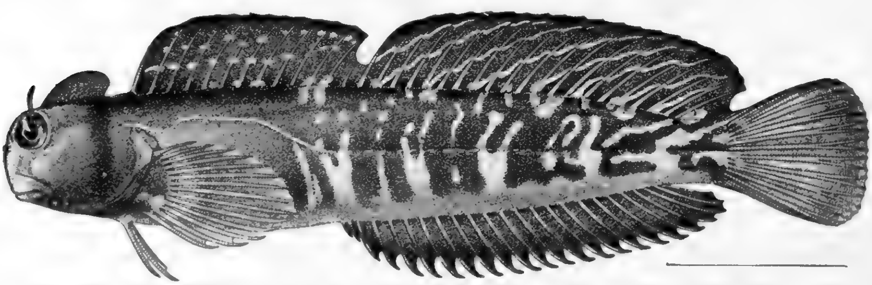


FIG. 453.—*Scartichthys enosimæ* Jordan & Snyder, a fish of the rock-pools of the sacred island of Enoshima, Japan. Family *Blenniidæ*.

Erpichthys atlanticus is found in abundance on both coasts of tropical America. Many species abound in Polynesia and in both Indies. *Salarias enosimæ* lives in the clefts of lava

rocks on the shores of Japan. *Ophioblennius* (*webbi*) is remarkable for its strong teeth, *Emblemaria* (*nivipes*, *Atlantica*) for its very high dorsal. Many other genera allied to *Blennius*, *Clinus*, and *Salarias* abound in the warm seas.

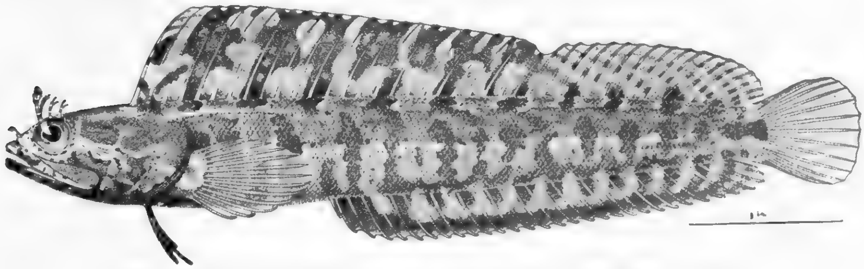


FIG. 454.—*Zacalles bryope* Jordan & Snyder. Misaki, Japan.

The Northern Blennies: Xiphidiinæ, Stichæiniæ, etc.—The blennies of the north temperate and arctic zones have the dorsal

FIG. 455.—*Bryostemma tarsodes* Jordan & Snyder. Unalaska.

fin more elongate, the dorsal fin usually but not always composed entirely of spines. The scales are small and the ventral

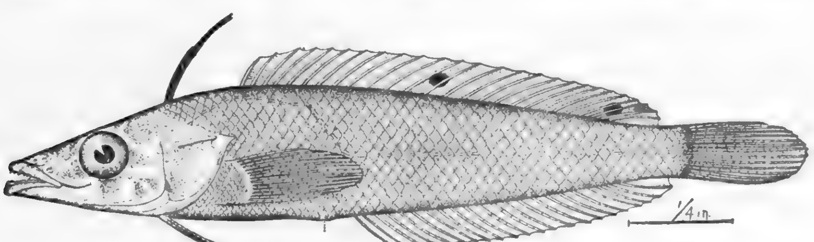


FIG. 456.—*Exerpes asper* Jenkins & Evermann, Guaymas, Mexico.
Family *Blenniidæ*.

fins generally reduced in size. These are divided by Dr. Gill into several distinct families, but the groups recognized by him are subject to intergradations.

Chirolophis (*ascanii*) of north Europe is remarkable for the tufted filaments on the head. These are still more developed in *Bryostemma* of the North Pacific, *Bryostemma polyactocephalum* and several other species being common from Puget Sound to Japan. *Apodichthys* (*flavidus*) of California is remarkable for a large quill-shaped anal spine and for the great variation in color, the hue being yellow, grass-green, or crimson, according to the color of the algæ about it. There is no evidence, however, that the individual fish can change its color, and these color forms seem to be distinct races within the species. *Xererpes fucorum* of California lies quiescent in the sea-weed (*Fucus*) after the tide recedes, its form, color, and substance seeming to correspond exactly with those of the stems of algæ. *Pholis gunnellus*

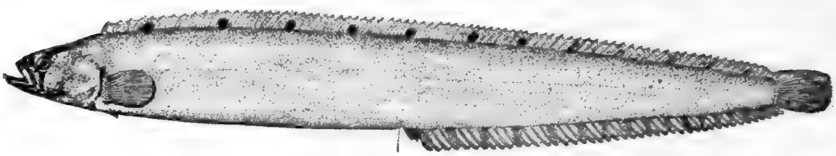


FIG. 457.—Gunnel, *Pholis gunnellus* (L.). Gloucester, Mass.

is the common gunnel (gunwale), or butter-fish, of both shores of the North Atlantic, with numerous allies in the North Pacific. Of these, *Enedrias nebulosus*, the ginpo, or silver-tail, is especially common in Japan. *Xiphidion* and *Xiphistes* of the California coast, and *Dictyosoma* of Japan, among others, are remarkable for the great number of lateral lines, these extending crosswise

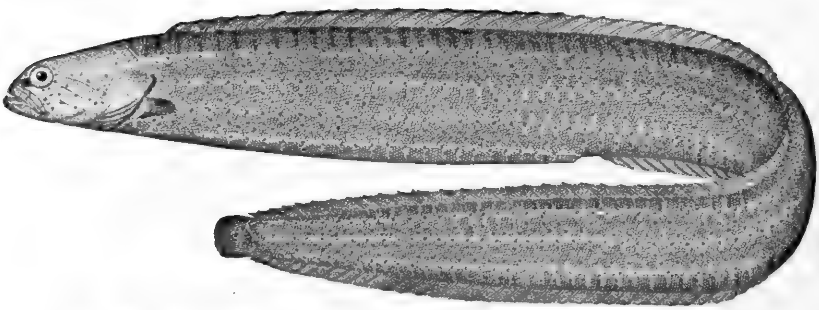


FIG. 458.—*Xiphistes chirus* Jordan & Gilbert. Amchitka I., Alaska.

as well as lengthwise. *Cebedichthys violaceus*, a large blenny of California, has the posterior half of the dorsal made of soft rays. *Opisthocentrus* of Siberia and north Japan has the dorsal spines

flexible, only the posterior ones being short and stiff. The snake-blennies (*Lumpenus*), numerous in the far North, are extremely slender, with well-developed pectorals and ventrals. *Lumpenus lampetræformis* is found on both shores of the Atlantic. In *Stichæus* a lateral line is present. There is none in *Lumpenus*, and in *Ernogrammus* and *Ozorthe* there are three. All these are elongate fishes, of some value as food and especially characteristic of the Northern seas. Fossil blennies are almost unknown. *Pterygocephalus paradoxus* of the Eocene resembles

FIG. 459.—*Ozorthe dictyogramma* (Hertzenstein), a Japanese blenny from Hakodate: showing increased number of lateral lines, a trait characteristic of many fishes of the north Pacific.

the living *Cristiceps*, a genus which differs from *Clinus* in having the first few dorsal spines detached, inserted on the head. The first spine alone in *Pterygocephalus* is detached and is very strong. A species called *Clinus gracilis* is described from the Miocene near Vienna, *Blennius fossilis* from the Miocene of Croatia, and an uncertain *Oncolepis isseli* from Monte Bolca. The family is certainly one of the most recent in geologic times. The family of *Blenniidæ*, as here recognized, includes a very great variety of forms and should perhaps be subdivided into several families, as Dr. Gill has suggested. At present there is, however, no satisfactory basis of division known.

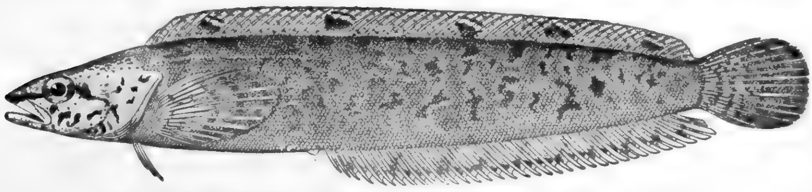


FIG. 460.—*Stichæus punctatus* Fabricius St. Michael, Alaska.

The Quillfishes: Ptilichthyidæ.—The *Ptilichthyidæ*, or quillfishes, are small and slender blennies of the North Pacific, with

very numerous fin-rays. *Ptilichthys goodei* has 90 dorsal spines and 145 soft rays. Another group of very slender naked blennies is the small family of *Xiphasiidæ* from the South Pacific.

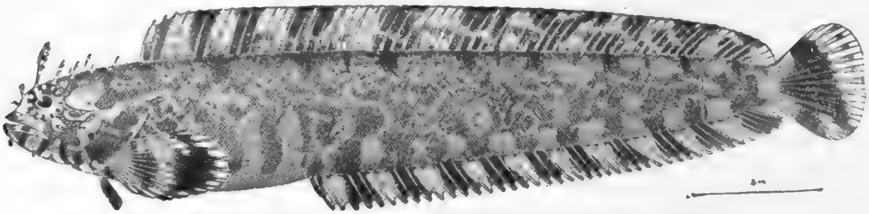


Fig. 461.—*Bryostemma otohime* Jordan & Snyder. Hakodate, Japan. Family *Blenniidæ*.

The jaws have excessively long canines; there are no ventral fins. The dorsal fin is very high and the caudal ends in a long thread.

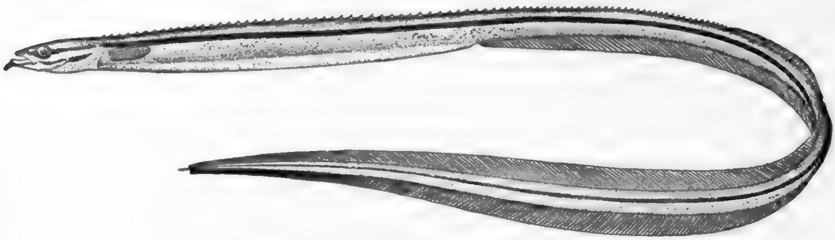


Fig. 462.—Quillfish, *Ptilichthys goodei* Bean. Unalaska.

The Blochiidæ.—Of doubtful relationship is the extinct family of *Blochiidæ*. In this group the body is elongate, covered with keeled plates imbricated like shingles. The

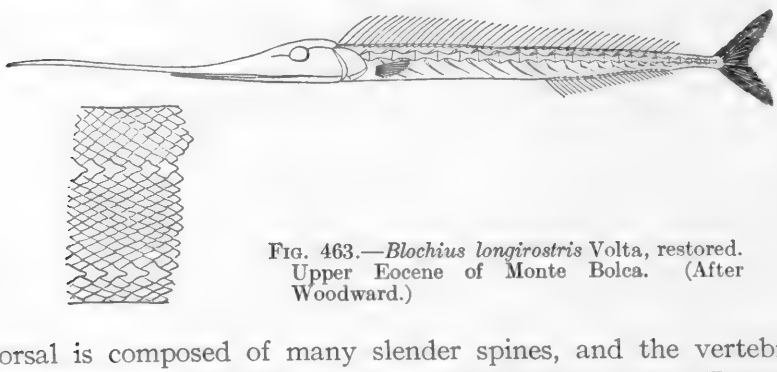


Fig. 463.—*Blochius longirostris* Volta, restored. Upper Eocene of Monte Bolca. (After Woodward.)

dorsal is composed of many slender spines, and the vertebræ much elongate. In *Blochius longirostris* (Monte Bolca Eocene)

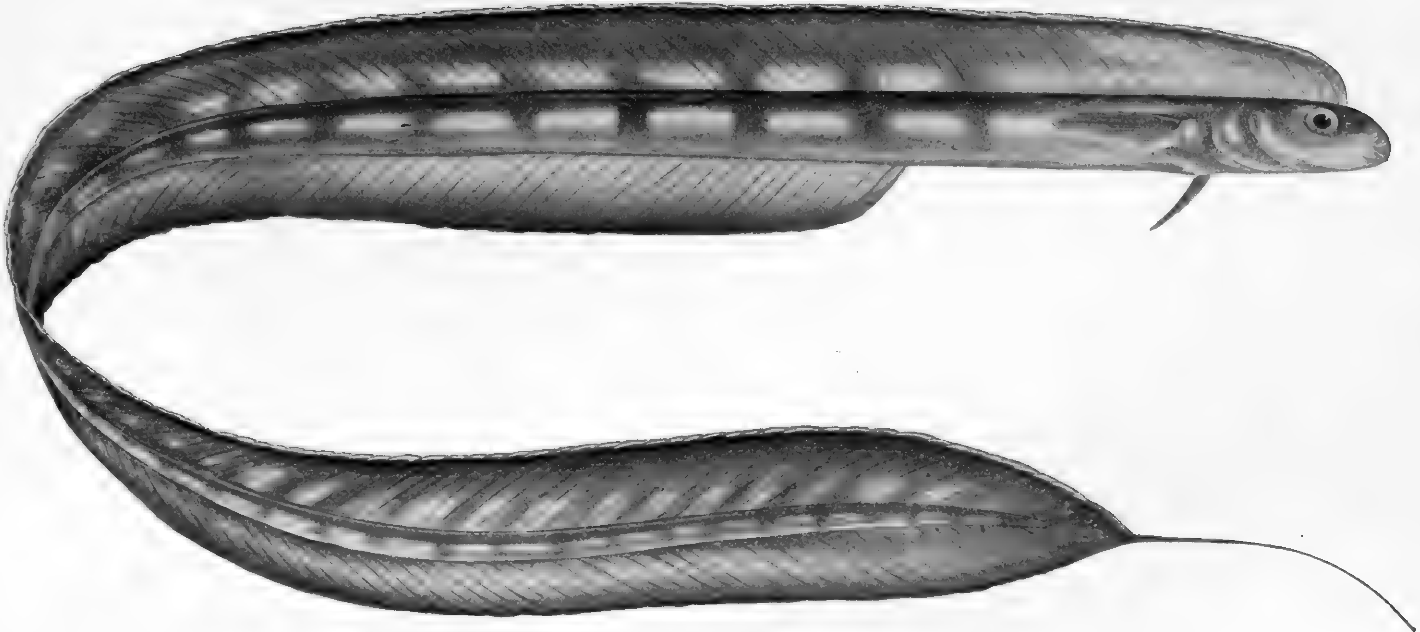


FIG. 464.—*Xiphasia setifera* Swainson. India. (After Day.)

has very long jaws, lined with small teeth. Zittel regards the family as allied to the *Belonorhynchidæ*, but the prolongation of the jaws may be a character of analogy merely. Woodward places it next to the *Blenniidæ*, supposing it to have small and jugular ventral fins. But as the presence of ventral fins is uncertain, the position of the family cannot be ascertained and it may really belong in the neighborhood of *Ammodytes*. The dorsal rays are figured by Woodward as simple.

The Patæcidæ, etc.—The *Patæcidæ* are blenny-like fishes of Australia, having the form of *Congriopus*, the spinous dorsal being very high and inserted before the eyes, forming a crest. *Patæcus fronto* is not rare in South Australia. The *Gnathanacanthidæ* is another small group of peculiar blennies from the Pacific. The *Acanthoclinidæ* are small blennies of New Zealand with numerous spines in the anal fin. *Acanthoclinus littoreus* is the only known species.

The Gadopsidæ, etc.—The family of *Gadopsidæ* of the rivers of New Zealand and southern Australia consists of a single species, *Gadopsis marmoratus*, resembling the scaly blennies called *Clinus*, but with long ventrals of a single ray, and three spines in the anal fin besides other peculiarities. The species is locally very common and with various other fishes in regions where true trout are unknown, it is called "trout."

The *Cerdalidæ* are small band-shaped blennies of the Pacific

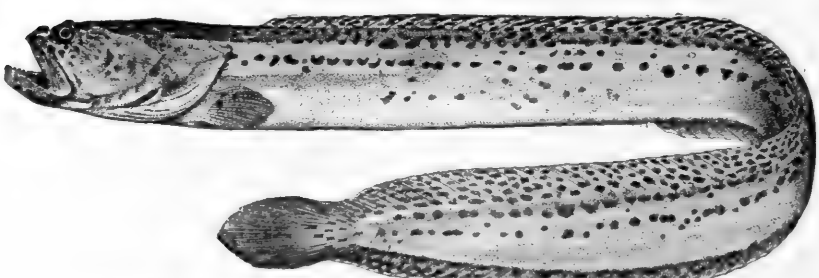


Fig. 465.—Wrymouth, *Cryptacanthodes maculatus*. New York.

coast of Panama. The slender dorsal spines pass gradually into soft rays. Three species are known.

The wrymouths, or *Cryptacanthodidæ*, are large blennies of the northern seas, with the mouth almost vertical and the

head cuboid. The wrymouth or ghostfish, *Cryptacanthodes maculatus*, is frequently taken from Long Island northward. It is usually dusky in color, but sometimes pure white. Other genera are found in the north Pacific.

The Wolf-fishes: Anarhichadidæ.—The wolf-fishes (*Anarhichadidæ*) are large blennies of the northern seas, remarkable for their strong teeth. Those in front are conical canines. Those behind are coarse molars. The dorsal is high, of flexible spines.

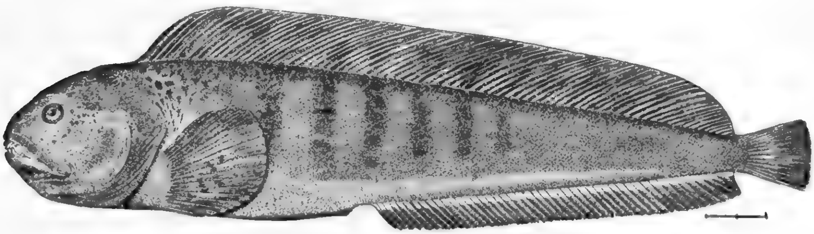


FIG 466.—Wolf-fish, *Anarhichas lupus* (L.). Georges Bank.

The species are large, powerful, voracious fishes, known as wolf-fishes. *Anarhichas lupus* is the common wolf-fish of the north Atlantic, reaching a length of four to six feet, the body

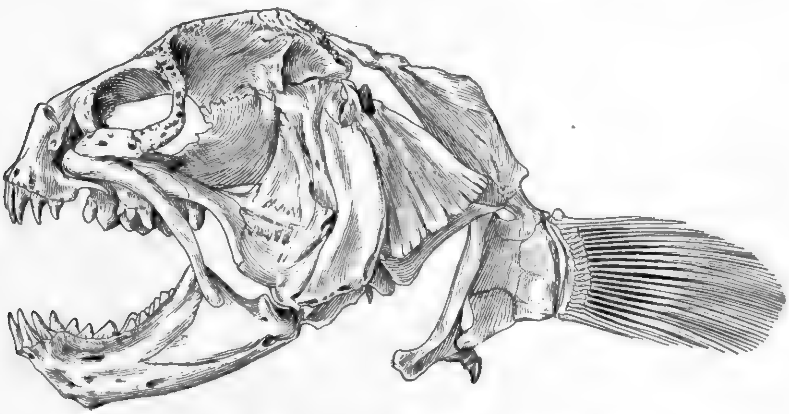


FIG. 467.—Skull of *Anarrhichthys ocellatus* Ayres.

marked by dark cross-bands. Other similar species are found both in the north Pacific and north Atlantic. *Anarhichas lepturus*, plain brown in color, is common about the Aleutian Islands.

In the wolf-eel (*Anarrhichthys ocellatus*) of the coast of California, the head is formed as in *Anarhichas* but the body is band-shaped, being drawn out into a very long and tapering tail. This species, which is often supposed to be a "sea-serpent," sometimes reaches a length of eight feet. It is used for food. It feeds on sea-urchins and sand-dollars (*Echinarachinius*) which it readily crushes with its tremendous teeth.

The skull of a fossil genus, *Laparus* (*alticeps*), with a resemblance to *Anarhichas*, is recorded from the Eocene of England.

The Eel-pouts: Zoarcidæ.—The remaining blenny-like forms lack fin spines, agreeing in this respect with the codfishes and their allies. In all of the latter, however, the hypercoracoid is imperforate, the pseudobranchiæ are obsolete, and the tail isocercal. The forms allied to *Zoarces* and *Ophidion*, and which we may regard as degraded blennies, have homocercal (rarely leptocercal) tails, generally but not always well-developed pseudobranchiæ and the usual foramen in the hypercoracoid.

The *Zoarcidæ*, or eel-pouts, have the body elongate, naked, or covered with small scales, the dorsal and anal of many soft rays and the gill-openings confined to the side. Most of the species live in rather deep water in the Arctic and Antarctic regions. *Zoarces viviparus*, the "mother of eels," is a common fish of the coasts of northern Europe. In the genus *Zoarces*,

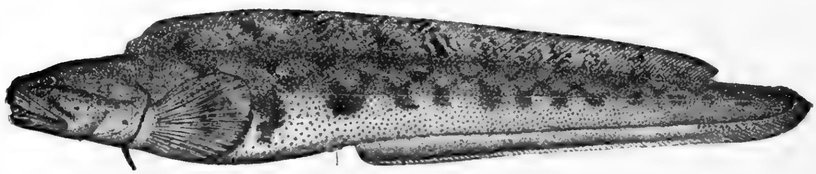


FIG. 468.—Eel-pout, *Zoarces anguillaris* Peck. Eastport, Me.

the last rays of the dorsal are short and stiff, like spines. The species are viviparous; the young being eel-like in form, the name "mother of eels" has naturally arisen in popular language. The American eel-pout, sometimes called mutton-fish, *Zoarces anguillaris*, is rather common north of Cape Cod, and a similar species, *Zoarces elongatus*, is found in northern Japan. *Lycodopsis pacifica*, without spines in the dorsal, replaces *Zoarces* in California. The species of *Lycodes*, without spines

in the dorsal, and with teeth on the vomer and palatines, are very abundant in the northern seas, extending into deep waters farther south. *Lycodes reticulatus* is the most abundant of these fishes, which are valued chiefly by the Esquimaux and

Fig. 469.—Eel-pout, *Lycodes reticulatus* Reinhardt. Banquereau.

other Arctic races of people. Numerous related genera are recorded from deep-sea explorations, and several others occur about Tierra del Fuego. *Gymnelis*, small, naked species brightly colored, is represented by *Gymnelis viridis* in the Arctic and by *Gymnelis pictus* about Cape Horn.

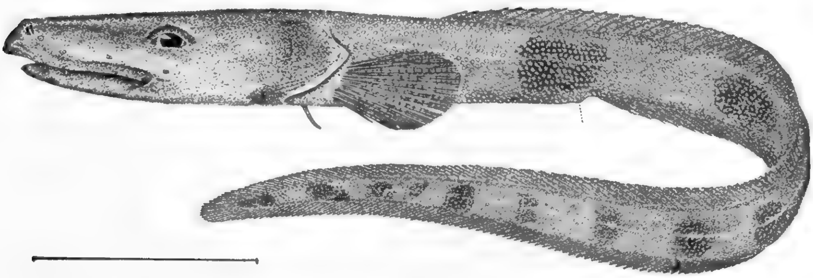


Fig. 470.—*Lycenchelys verrilli* (Goode & Bean). Chebucto, Nova Scotia.

The family of *Scytalinidæ* contains a single species, *Scytalina cerdale*, a small snake-shaped fish which lives in wet gravel between tide-marks, on Waada Island near Cape Flattery in Washington, not having yet been found elsewhere. It dives

Fig. 471.—*Scytalina cerdale* Jordan & Gilbert. Straits of Fuca.

among the wet stones with great celerity, and can only be taken by active digging.

To the family of *Congrogadidæ* belong several species of

eel-shaped blennies with soft rays only, found on the coasts of Asia. Another small family, *Derepodichthyidæ*, is represented by one species, a scaleless little fish from the shores of British Columbia.

The *Xenocephalidæ* consist of a single peculiar species, *Xenocephalus armatus*, from the island of New Ireland. The head is very large, helmeted with bony plates and armed with spines. The body is short and slender, the ventrals with five rays, the dorsal and anal short.

The Cusk-eels: Ophidiidæ. — The more important family of *Ophidiidæ*, or cusk-eels, is characterized by the extremely anterior position of the ventral fins, which are inserted at the throat, each one appearing as a long forked barbel. The tail is lepto-

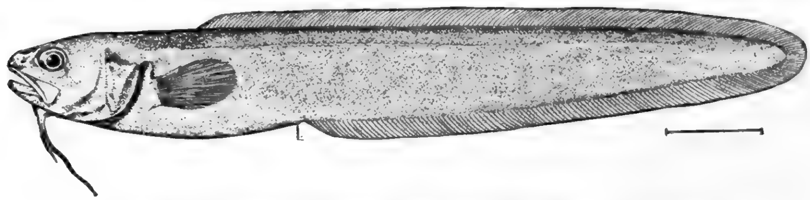


Fig. 472.—Cusk-eel, *Rissola marginata* (De Kay). Virginia.

cercal, attenuate, the dorsal and anal confluent around it. *Ophidion barbatum* and *Rissola rochei* are common in southern Europe. *Rissola marginata* is the commonest species on our Atlantic coast, and *Chilara taylori* in California. Other species are found farther south, and still others in deep water. *Genypterus* contains numerous species of the south Pacific, some of which reach the length of five feet, forming a commercial substitute for cod. *Genypterus capensis* is the klipvisch of the Cape of Good Hope, and *Genypterus australis* the "Cloudy Bay cod" or "rock ling" of New England. Another large species,

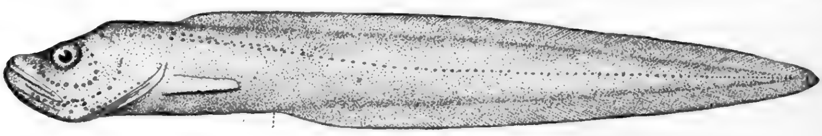


Fig. 473.—*Lycodapus dermatinus* Gilbert. Lower California.

Genypterus maculatus, occurs in Chile. A few fragments doubtfully referred to *Ophidion* and *Fierasfer* occur in the Eocene and later rocks. The *Lycodapodidæ* contain a few small, scaleless fishes (*Lycodapus*) dredged in the north Pacific.

Sand-lances: Ammodytidæ. — Near the *Ophidiidæ* are placed the small family of sand-lances (*Ammodytidæ*). This family comprises small, slender, silvery fishes, of both Arctic and tropical seas, living along shore and having the habit of burying themselves in the sand under the surf in shallow water. The jaws are toothless, the body scarcely scaly and crossed by many cross-folds of skin, the many-rayed dorsal fin is without spines, and the ventral fins when present are jugular. The species of the family are very much alike. From their great abundance they have sometimes much value as food, more perhaps as bait, still more as food for salmon and other fishes, from which they escape by plunging into the sand. Sometimes a falling tide

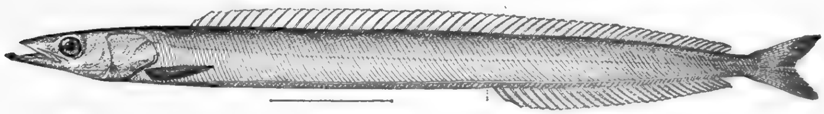


FIG. 474.—Sand-lance, *Ammodytes americanus* De Kay. Nantucket.

leaves a sandy beach fairly covered with living "lants" looking like a moving foam of silver. *Ammodytes tobianus* is the sand-lance or lant of northern Europe. *Ammodytes americanus*, scarcely distinguishable, replaces it in America; and *Ammodytes personatus* in California, Alaska, and Japan. This is a most excellent pan fish, and the Japanese, who regard little things, value it highly.

In the genus *Hyperoplus* there is a large tooth on the vomer. In the tropical genera there is a much smaller number of vertebræ and the body is covered with ordinary scales instead

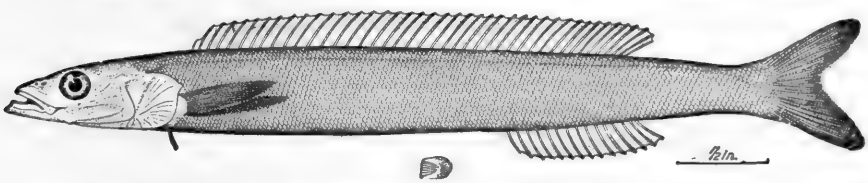


FIG. 475.—*Embolichthys mitsukurii* (Jordan & Evermann). Formosa.

of delicate, oblique cross-folds of skin. These tropical species must probably be detached from the *Ammodytidæ* to form a distinct family, *Bleekeriidæ*. *Bleekeria kallolepis* is found in India, *Bleekeria gilli* is from an unknown locality, and the most primitive species of sand-lance, *Embolichthys mitsukurii*,

occurs in Formosa. In this species, alone of the sand-lances, the ventral fins are retained. These are jugular in position, as in the *Zoarcidæ*, and the rays are I, 3. The discovery of this species makes it necessary to separate the *Ammodytidæ* and *Bieekeriidæ* widely from the *Percesoces*, and especially from the extinct families of *Crossognathidæ* and *Cobitopsidæ* with which its structure in other regards has led Woodward, Boulenger, and the present writer to associate it.

Although an alleged sand-lance, *Rhynchias septipinnis*, with ventral fins abdominal, was described a century ago by Pallas, no one has since seen it, and it may not exist, or, if it exists, it may belong among the *Percesoces*. The relation of *Ammodytes* to *Embolichthys* is too close to doubt their close relationship. According to Dr. Gill the *Ammodytidæ* belong near the *Hemerocœtidæ*.

The Pearlfishes: Fierasferidæ.—In the little group of pearlfishes, called *Fierasferidæ* or *Carapidæ*, the body is eel-shaped

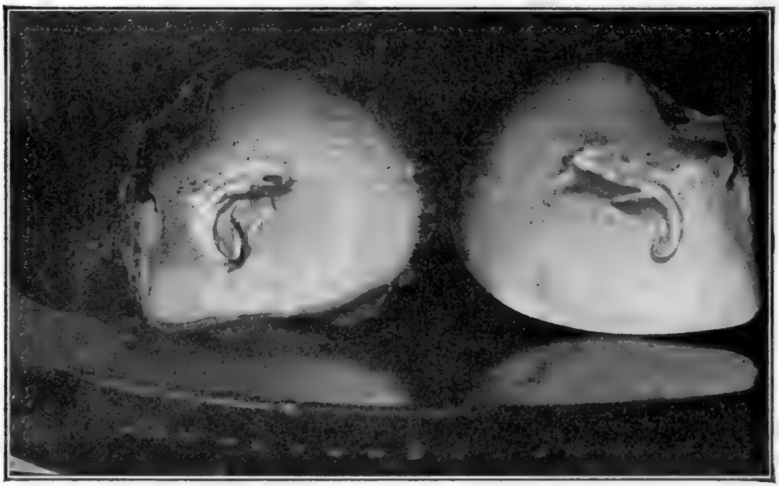


Fig. 476.—Pearlfish, *Fierasfer dubius* Putnam, embedded in a layer of mother-of-pearl. La Paz, Lower California. (Photograph by Capt. M. Castro.)

with a rather large head, and the vent is at the throat. Numerous species of *Fierasfer* (*Carapus*) are found in the warm seas. These little fishes enter the cavities of sea-cucumbers (Holothurians) and other animals which offer shelter, being frequently taken from the pearl-oyster. In the Museum of Comparative

Zoology, according to Professor Putnam, is "one valve of a pearl-oyster in which a specimen of *Fierasfer dubius* is beautifully inclosed in a pearly covering deposited on it by the oyster." A photograph of a similar specimen is given above. The species found in Holothurians are transparent in texture, with a bright pearly luster. Species living among lava rocks, as *Jordanicus umbratilis* of the south seas, are mottled black. Since this was written a specimen of this black species has been obtained from a Holothurian in Hilo, Hawaii, by Mr. H. W. Henshaw.

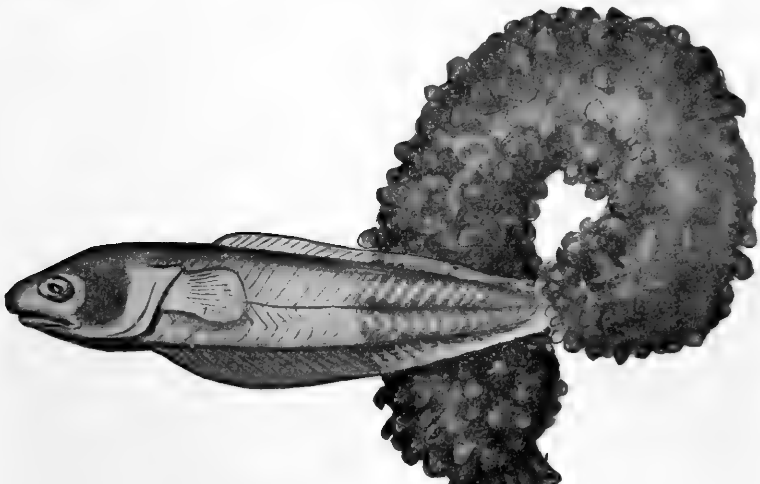


FIG. 477.—Pearlfish, *Fierasfer acus* (Linnæus), issuing from a Holothurian. Coast of Italy. (After Emery.)

The Brotulidæ.—The *Brotulidæ* constitute a large family of fishes, resembling codfishes, but differing in the character of the hypercoracoid, as well as in the form of the tail. The resemblance between the two groups is largely superficial. We may look upon the *Brotulidæ* as degraded blennies, but the *Gadidæ* have an earlier and different origin which has not yet been clearly made out. Most of the *Brotulidæ* live in deep water and are without common name or economic relations. Two species have been landlocked in cave streams in Cuba, where they have, like other cavefishes, lost their sight, a phenomenon which richly deserves careful study, and which has been recently investigated by Dr. C. H. Eigenmann. These blind

Brotulids, called Pez Ciego in Cuba, are found in different caves in the county of San Antonio, where they reach a length of about five inches. As in other blindfishes, the body is translu-

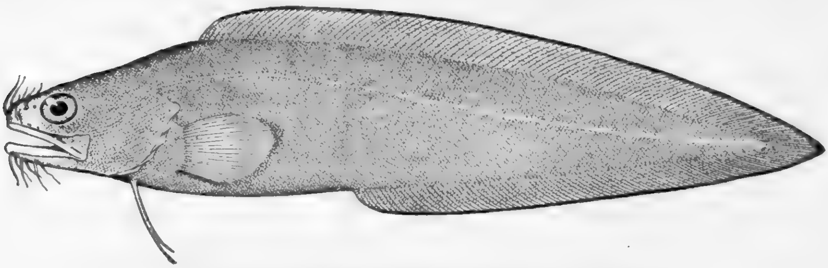


Fig. 478.—*Brotula barbata* Schneider. Cuba.

cent and colorless. These species are known as *Lucifuga subterranea* and *Stygicola dentata.* They are descended from allies of the genera called *Brotula* and *Dinematichthys. Brotula barbata* is a cusk-like fish, occasionally found in the markets of

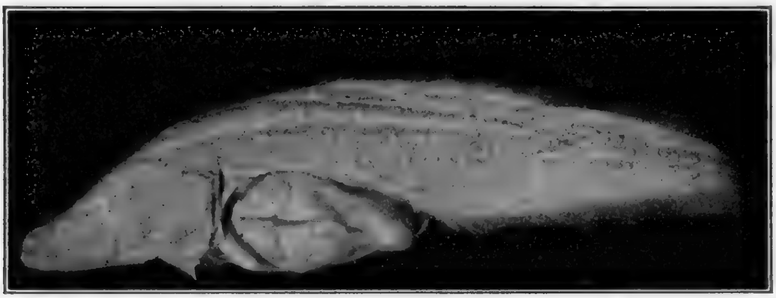


Fig. 479.—Blind Brotula. *Lucifuga subterranea* (Poey), showing viviparous habit. Joignan Cave, Pinar del Rio, Cuba. (Photograph by Dr. Eigenmann.)

Havana. Similar species, *Brotula multibarbata* and *Sirembo inermis*, are common in Japan, and *Brosmophycis marginatus*, beautifully red in color, is occasionally seen on the coast of California. Many other genera and species abound in the depths of the sea and in crevices of coral reefs, showing much variety in form and structure.

The *Bregmacerotidæ* are small fishes, closely related to the Brotulids, having the hypercoracoid perforate, but with several minor peculiarities, the first ray of the dorsal being free and much elongate. They live near the surface in the open sea. *Bregmaceros macclellandi* is widely diffused in the Pacific.

Ateleopodidæ.—The small family of *Ateleopodidæ* includes long-bodied, deep-water fishes of the Pacific, resembling *Macrourus*, but with smooth scales. The group has the coracoids as in *Brotulidæ*, and the actinosts are united in an undivided plate. *Ateleopus japonicus* is the species taken in Japan.

Suborder Haplodoci.—We may here place the peculiar family of *Batrachoididæ*, or toadfishes. It constitutes the suborder of *Haplodoci* (ἁπλόος, simple; δόκος, shaft) from the simple form of the post-temporal. This order is characterized by the undivided post-temporal bone and by the reduction of the gill-arches to three. A second bone behind the post-temporal connects the shoulder-girdle above to the vertebral column. The coracoid bones are more or less elongate, suggesting the arm seen in pediculate fishes.

The single family has the general form of the *Cottidæ*, the body robust, with large head, large mouth, strong teeth, and short spinous dorsal fin. The shoulder-girdle and its structures differ little from the blennioid type. There are no pseudobranchiæ and the tail is homocercal. The species are relatively few, chiefly confined to the warm seas and mostly American, none being found in Europe or Asia. Some of them ascend rivers, and all are carnivorous and voracious. None are valued

FIG. 480.—Leopard Toadfish, *Opsanus pardus* (Goode & Bean). Pensacola.

as food, being coarse-grained in flesh. The group is probably nearest allied to the *Trachinidæ* or *Uranoscopidæ*.

Opsanus tau, the common toadfish, or oyster-fish, of our Atlantic coast, is very common in rocky places, the young clinging to stones by a sucking-disk on the belly, a structure

which is early lost. It reaches a length of about fifteen inches. *Opsanus pardus*, the leopard toadfish, or sapo, of the Gulf coast, lives in deeper water and is prettily marked with dark-brown spots on a light yellowish ground.

In *Opsanus* the body is naked and there is a large foramen, or mucous pore, in the axil of the pectoral. In the *Marcgravia cryptocentra*, a large Brazilian toadfish, this foramen is absent. In *Batrachoides*, a South American genus, the body is covered with cycloid scales. *Batrachoides surinamensis* is a common species of the West Indies. *Batrachoides pacifici* occurs at Panama. The genus *Porichthys* is remarkable for the development of series of mucous pores and luminous spots in several different lateral lines which cover the body. These luminous spots are quite unlike those found in the lantern-fishes (*Myctophidæ*) and other *Iniomi*. Their structure has been worked out in detail by Dr. Charles Wilson Greene, a summary of whose conclusions are given on page 191, Vol. I.

The common midshipman, or singing fish, of the coast of California is *Porichthys notatus*. This species, named midshipman from its rows of shining spots like brass buttons, is found among rocks and kelp and makes a peculiar quivering or humming noise with its large air-bladder.

Porichthys porosissimus, the bagre sapo, is common on all coasts of the Gulf of Mexico and the Caribbean Sea. *Po-*

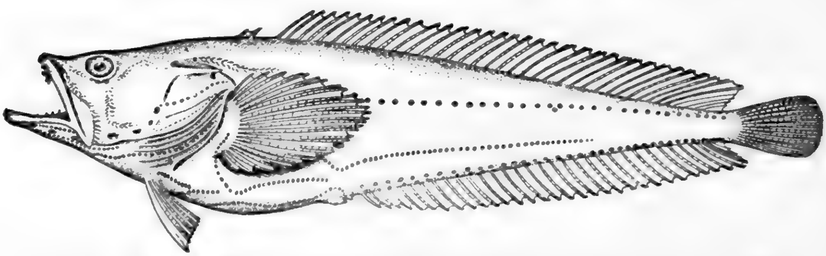


FIG. 481.—Singing Fish or Bagre Sapo, *Porichthys porosissimus* (Cuv. & Val.). Galveston.

richthys margaritatus is found about Panama and *Porichthys porosus* in Chile.

The species of *Thalassophryne* and *Thalassothia*, the poison toadfishes, are found along the coasts of South America, where they sometimes ascend the rivers. In these species there is

an elaborate series of venom glands connected with the hollow spines of the opercle and the dorsal spines. Dr. Günther gives the following account of this structure as shown in *Thalassophryne reticulata*, a species from Panama:

"In this species I first observed and closely examined the poison organ with which the fishes of this genus are provided. Its structure is as follows: (1) The opercular part: The operculum is very narrow, vertically styliform and very mobile; it is armed behind with a spine, eight lines long in a specimen of 10½ inches, and of the same form as the venom fang of a snake; it is, however, somewhat less curved, being only slightly bent upward. It has a longish slit at the outer side of its extremity which leads into a canal perfectly closed and running along the whole length of its interior; a bristle introduced into the canal reappears through another opening at the base of the spine, entering into a sac situated on the opercle and along the basal half of the spine; the sac is of an oblong-ovate shape and about double the size of an oat grain. Though the specimen had been preserved in spirits for about nine months it still contained a whitish substance of the consistency of thick cream, which on the slightest pressure freely flowed from the opening in the extremity of the spine. On the other hand, the sac could be easily filled with air or fluid from the foramen of the spine. No gland could be discovered in the immediate neighborhood of the sac; but on a more careful inspection I found a minute tube floating free in the sac, whilst on the left-hand side there is only a small opening instead of the tube. The attempts to introduce a bristle into this opening for any distance failed, as it appears to lead into the interior of the basal portion of the operculum, to which the sac firmly adheres at this spot. (2) The dorsal part is composed of the two dorsal spines, each of which is ten lines long. The whole arrangement is the same as in the opercular spines; their slit is at the front side of the point; each has a separate sac, which occupies the front of the basal portion; the contents were the same as in the opercular sacs, but in somewhat greater quantity. A strong branch of the lateral line ascends to the immediate neighborhood of their base. Thus we have four poison spines, each with a sac at its base; the walls of the sacs are thin, composed of a fibrous membrane,

the interior of which is coated over with mucus. There are no secretory glands embedded between these membranes, and these sacs are probably merely the reservoirs in which the fluid secreted accumulates. The absence of a secretory organ in the immediate neighborhood of the reservoirs (an organ the size of which would be in accordance with the quantity of fluid secreted), the diversity of the osseous spines which have been modified into poison organs, and the actual communication indicated by the foramen in the sac lead me to the opinion that the organ of secretion is either that system of muciferous channels which is found in nearly the whole class of fishes, and the secretion of which has poisonous qualities in a few of them, or at least an independent portion of it. This description was made from the first example; through the kindness of Captain Dow I received two other specimens, and in the hope of proving the connection of the poison bags with the lateral-line system, I asked Dr. Pettigrew, of the Royal College of Surgeons, a gentleman whose great skill has enriched that collection with a series of the most admirable anatomical preparations, to lend me his assistance in injecting the canals. The injection of the bags through the opening of the spine was easily accomplished; but we failed to drive the fluid beyond the bag or to fill with it any other part of the system of muciferous channels. This, however, does not disprove the connection of the poison bags with that system, inasmuch as it became apparent that if there be minute openings they are so contracted by the action of the spirit in which the specimens were preserved as to be impassable to the fluid of injection. A great part of the lateral-line system consists of open canals; however, on some parts of the body, these canals are entirely covered by the skin; thus, for instance, the open lateral line ceases apparently in the suprascapular region, being continued in the parietal region. We could not discover any trace of an opening by which the open canal leads to below the skin; yet we could distinctly trace the existence of the continuation of the canal by a depressed line, so that it is quite evident that such openings do exist, although they may be passable only in fresh specimens. Thus likewise the existence of openings in the bags, as I believed to have found in the first specimen dissected, may be proved by examination

of fresh examples. The sacs are without an external muscular layer and situated immediately below the loose thick skin which envelops their spines to their extremity. The injection of the poison into a living animal, therefore, can only be effected by the pressure to which the sac is subjected the moment the spine enters another body. Nobody will suppose that a complicated apparatus like the one described can be intended for conveying an innocuous substance, and therefore I have not hesitated to designate it as poisonous; and, Captain Dow informs me in a letter lately received, 'the natives of Panama seemed quite familiar with the existence of the spines and of the emission from them of a poison which, when introduced into a wound, caused fever, an effect somewhat similar to that produced by the sting of a scorpion; but in no case was a wound caused by one of them known to result seriously. The slightest pressure of the finger at the base of the spine caused the poison to jet a foot or more from the opening of the spine.' The greatest importance must be attached to this fact, inasmuch as it assists us in our inquiries into the nature of the functions of the muciferous system, the idea of its being a secretory organ having lately been superseded by the notion that it serves merely as a stratum for the distribution of peripheric nerves. Also the objection that the sting-rays and many Siluroid fishes are not poisonous because they have no poison organ cannot be maintained, although the organs conveying their poison are neither so well adapted for this purpose nor in such a perfect connection with the secretory mucous system as in *Thalassophryne*. The poison organ serves merely as a weapon of defense. All the Batrachoids with obtuse teeth on the palate and in the lower jaw feed on Mollusca and Crustaceans."

No fossil *Batrachoididæ* are known.

Suborder Xenopterygii.—The clingfishes, forming the suborder *Xenopterygii* (ξενός, strange; πτερύξ, fin), are, perhaps, allied to the toadfishes. The ventral fins are jugular, the rays I, 4 or I, 5, and between them is developed an elaborate sucking-disk, not derived from modified fins, but from folds of the skin and underlying muscles.

The structure of this disk in *Gobiesox sanguineus* is thus described by Dr. Günther:

"The whole disk is exceedingly large, subcircular, longer than broad, its length being (often) one-third of the whole length of the fish. The central portion is formed merely by skin, which is separated from the pelvic or pubic bones by several layers of muscles. The peripheric portion is divided into an anterior and posterior part by a deep notch behind the ventrals. The anterior peripheric portion is formed by the ventral rays, the membrane between them and a broad fringe which extends anteriorly from one ventral to the other. This fringe is a fold of the skin, containing on one side the rudimentary ventral spine, but no cartilage. The posterior peripheric portion is suspended on each side on the coracoid, the upper bone of which is exceedingly broad, becoming a free, movable plate behind the pectoral. The lower bone of the coracoid is of a triangular form, and supports a very broad fold of the skin, extending from one side to the other, and containing a cartilage which runs through the whole of that fold. Fine processes of the cartilage are continued into the soft striated margin, in which the disk terminates posteriorly. The face of the disk is coated with a thick epidermis, like the sole of the foot in higher animals. The epidermis is divided into many polygonal plates. There are no such plates between the roots of the ventral fins."

The body is formed much as in the toadfishes. The skin is naked and there is no spinous dorsal fin. The skeleton shows

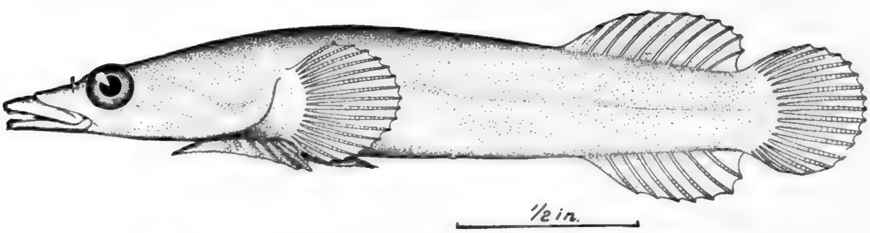


FIG. 482.—*Aspasma ciconiæ* Jordan & Snyder. Wakanoura, Japan.

several peculiarities; there is no suborbital ring, the palatine arcade is reduced, as are the gill-arches, the opercle is reduced to a spine-like projection, and the vertebræ are numerous. The species are found in tide-pools in the warm seas, where they cling tightly to the rocks with their large ventral disks.

Several species of *Lepadogaster* and *Mirbelia* are found in the Mediterranean. *Lepadogaster gouani* is the best-known European species. *Aspasma ciconiæ* and *minima* occur about the rocks in the bays of Japan.

Most of the West Indian species belong to *Gobiesox*, with entire teeth, and to *Arbaciosa*, with serrated teeth. Some of these

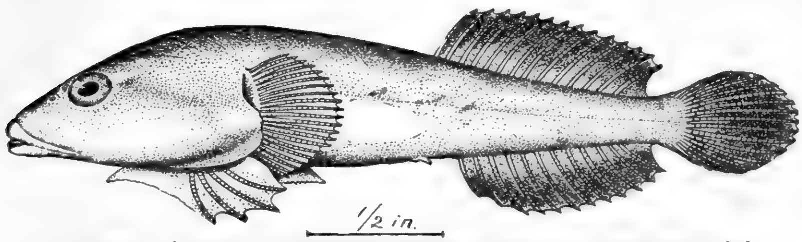


Fig. 483.—Clingfish, *Caularchus mœandricus* (Girard). Monterey, Cal.

species are deep crimson in color, but most of them are dull olive. *Gobiesox virgatulus* is common on the Gulf Coast. *Caularchus mœandricus*, a very large species, reaching a length of six inches, abounds along the coast of California. Other genera are found at the Cape of Good Hope, especially about New Zealand. *Chorisochismus dentex*, from the Cape of Good Hope, reaches the length of a foot.

CHAPTER XXX

OPISTHOMI AND ANACANTHINI

ORDER Opisthomi.—The order *Opisthomi* (ὄπισθη, behind; ὦμος, shoulder) is characterized by the general traits of the blennies and other elongate, spiny-rayed fishes, but the shoulder-girdle, as in the Apodes and the *Heteromi*, is inserted on the vertebral column well behind the skull.

The single family, *Mastacembelidæ*, is composed of eel-shaped fishes with a large mouth and projecting lower jaw, inhabiting the waters of India, Africa, and the East Indies. They are small in size and of no economic importance. The dorsal is long, with free spines in front and there are no ventral fins. Were these fins developed, they should in theory be jugular in position. There is no air-duct in *Mastacembelus* and it seems to be a true spiny-rayed fish, having no special relation to

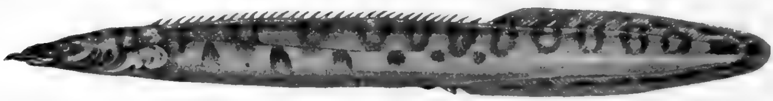


FIG. 484.—*Mastacembelus ellipsifer* Boulenger. Congo River. (After Boulenger.)

either *Notacanthus* or to the eels. Except for the separation of the shoulder-girdle from the skull, there seems to be no reason for separating them far from the Blennioid forms, and the resemblance to *Notacanthus* seems wholly fallacious.

Mastacembelus armatus is a common species of India and China. In *Rhynchobdella* the nasal appendage or proboscis, conspicuous in *Mastacembelus*, is still more developed. *Rhynchobdella aculeata* is common in India.

Order Anacanthini.—We may separate from the other jugular fishes the great group of codfishes and their allies,

retaining the name Anacanthini (ἄνακανθος, without spine) suggested by Johannes Müller. In this group the hyper-coracoid is without foramen, the fenestra lying between this bone and the hypocoracoid below it. The tail is isocercal, the vertebræ in a right line and progressively smaller backward, sometimes degenerate or whip-like (leptocercal) at tip. Other characters are shown in the structure of the skull. There are no spines in any of the fins; the ventrals are jugular, the scales generally small, and the coloration dull or brownish. The numerous species live chiefly in the northern seas, some of them descending to great depths. The resemblance of these fishes to some of the Blennioid group is very strongly marked, but these likenesses seem analogical only and not indicative of true affinity. The codfishes probably represent an early offshoot from the ancestors of the spiny-rayed fishes, and their line of evolution is unknown, possibly from Ganoid types. Among recent fishes there is nothing structurally nearer than the *Nototheniidæ* and *Brotulidæ*, but the line of descent must branch off much farther back than either of these. For the present, therefore, we may regard the codfishes and their allies (*Anacanthini*) as a distinct order.

The Codfishes: Gadidæ.—The chief family is that of the *Gadidæ*, or codfishes. These are characterized by a general resemblance to the common codfish, *Gadus callarias*. This is one of the best

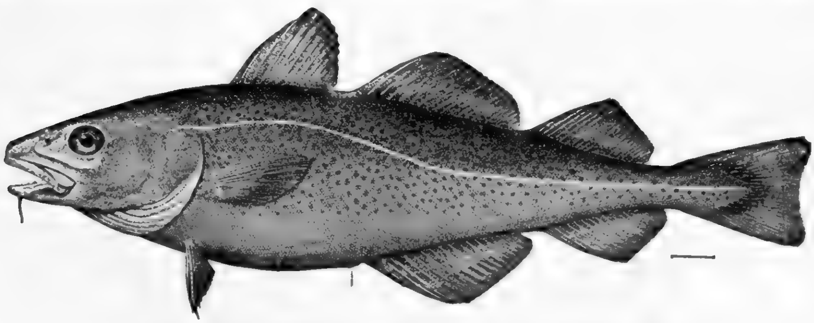


Fig. 485.—Codfish, *Gadus callarias* L. Eastport, Me.

known of fishes, found everywhere on the shores of the North Atlantic, and the subject of economic fisheries of the greatest importance. Its flesh is white, flaky, rather tasteless, but takes salt readily, and is peculiarly well adapted for drying. The average size of the codfish is about ten pounds, but Captain

Nathaniel Atwood of Provincetown records one with the weight of 160 pounds.

According to Dr. Goode:

"In the western Atlantic the species occurs in the winter in considerable abundance as far south as the mouth of the Chesapeake Bay, latitude 37°, and stragglers have been observed about Ocracoke Inlet. The southern limits of the species may be safely considered to be Cape Hatteras, in latitude 35° 10′. Along the coast of New England, the Middle States, and British North America, and upon all the off-shore banks of this region, cod are found usually in great abundance, during part of the year at least. They have been observed also in the Gulf of Bothnia, latitude 70° to 75°, and in the southeastern part of Baffin's Land to the northward of Cumberland Sound, and it is more than probable that they occur in the waters of the Arctic Sea to the north of the American continent, or away around to Bering Strait."

Dr. Gill says:

"The ocean banks of moderate depths are the favorite resorts of the cod, but it is by no means confined to those localities. The fish, indeed, occasionally enters into fresh, or at least brackish, water. According to Canadian authorities, it is found 'well up the estuary of the St. Lawrence, though how far up is not definitely stated, probably not beyond the limits of brackish water.' Even as far south as the Delaware River it has been known to enter the streams. Dr. C. C. Abbott records that in January, 1876, 'a healthy, strong, active codfish, weighing nearly four pounds, was taken in a draw-net in the Delaware River near Trenton, New Jersey; the stomach of the fish showed that it had been in river-water several days. Many of them had been taken about Philadelphia between 1856 and 1869.'

"The cod ranks among the most voracious of ordinary fishes, and almost everything that is eatable, and some that is not, may find its way into its capacious maw. Years ago, before naturalists had the facilities that the dredge now affords, cods' stomachs were the favorite resort for rare shells, and some species had never been obtained otherwise than through such a medium, while many filled the cabinet that would not other-

wise have been represented. In the words of Mr. Goode, 'codfish swallow bivalve fish of the largest size, like the great sea-clams, which are a favorite article of food on certain portions of the coast'; further, 'these shells are nested, the smaller inside of the larger, sometimes six or seven in a set, having been packed together in this compact manner in the stomachs of the codfish after the soft parts have been digested out. Some of them had shreds of the muscles remaining in them and were quite fresh, having evidently been but recently ejected by the fish.' Even banks of dead shells have been found in various regions, which are supposed to be the remains of mollusks taken by the cod. Shell-fishes, however, form probably but the smaller portion of its diet, and fishes of its own class contribute materially to its food,—such as the herring family, the capelin, etc.

"The codfish in its mode of reproduction exhibits some interesting peculiarities. It does not come on the coast to spawn, as was once supposed, but its eggs are deposited in mid-sea and float to the surface, although it does really, in many cases, approach the land to do so. Prof. C. O. Sars, who has discovered its peculiarities, 'found cod at a distance of twenty to thirty Norwegian miles from the shore and at a depth of from one hundred to one hundred and fifty fathoms.' The eggs thus confided to the mercy of the waves are very numerous; as many as 9,100,000 have been calculated in a seventy-five-pound fish. 'When the eggs are first seen in the fish they are so small as to be hardly distinguishable; but they continue to increase in size until maturity, and after impregnation have a diameter depending upon the size of the parent, varying from one-nineteenth to one-seventeenth of an inch. A five- to eight-pound fish has eggs of the smaller size, while a twenty-five-pound one has them between an eighteenth and a seventeenth.' There are about 190,000 eggs of the smaller size to a pound avoirdupois. They are matured and ejected from September to November."

Unlike most fishes, the cod spawns in cooling water, a trait also found in the salmon family.

The liver of the cod yields an easily digested oil of great value in the medical treatment of diseases causing emaciation.

The Alaska cod, *Gadus macrocephalus*, is equally abundant with the Atlantic species, from which it differs very slightly, the air-bladder or sounds being smaller, according to the fisher-

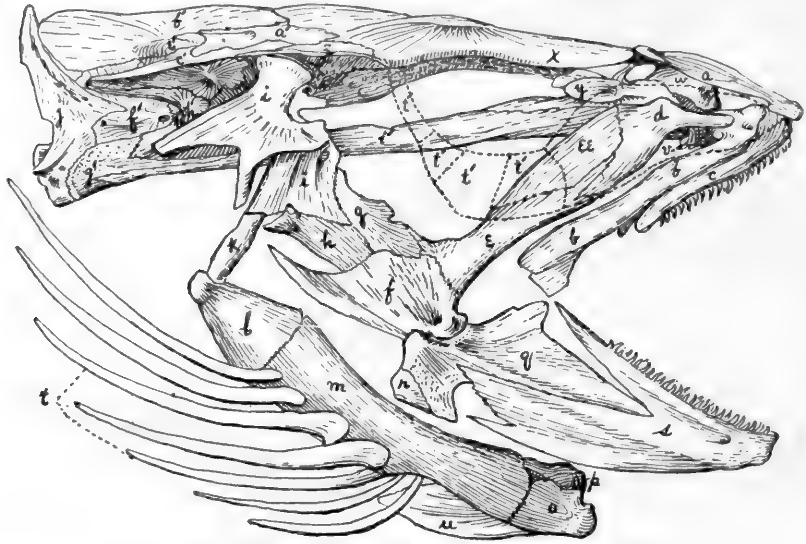


FIG. 486.—Skull of Haddock, *Melanogrammus æglifinus*.

men, and the head being somewhat larger. This species is found from Cape Flattery to Hakodate in Japan, and is very abundant about the Aleutian Islands and especially in the Okhotsk Sea.

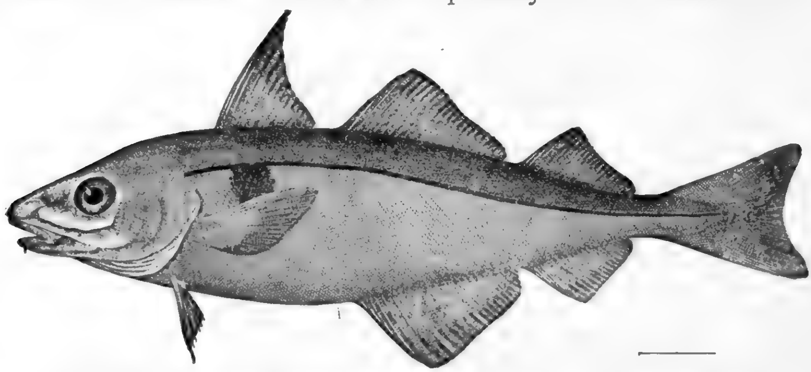


FIG. 487.—Haddock, *Melanogrammus æglifinus* (L.). Eastport, Me.

With equal markets it would be as important commercially as the Atlantic cod. In the codfish (*Gadus*) and related genera there are three dorsal and two anal fins. In the codfish the lateral line is pale and the lower jaw shorter than the upper.

The haddock (*Melanogrammus æglifinus*) closely resembles the cod and is of similar quality as food. It is known at sight by the black lateral line. It is found on both shores of the Atlantic and when smoked is the "finnan haddie" of commerce.

The pollack, coalfish, or green cod (*Pollachius carbonarius*) is also common on both shores of the north Atlantic. It is darker than the cod and more lustrous, and the lower jaw is longer, with a smaller barbel at tip. It is especially excellent when fresh.

The whiting (*Merlangus merlangus*) is a pollack-like fish common on the British coasts, but not reaching the American shores.

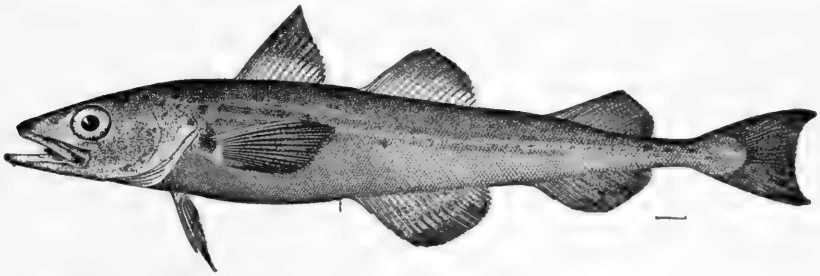


FIG. 488.—Pollock, *Theragra chalcogramma* (Pallas). Shumagin I., Alaska.

It is found in large schools in sandy bays. The Alaska pollack (*Theragra chalcogramma*) is a large fish with projecting lower jaw, widely diffused in the north Pacific and useful as a food-fish to the Aleutian peoples. It furnishes a large part of the food of the fur-seal (*Callorhinus alascanus* and *C. ursinus*) during its migrations. The fur-seal rarely catches the true codfish, which swims near the bottom. The wall-eyed pollack (*Theragra fucensis*) is found about Puget Sound. Smaller codfishes of this type are the wachna cod (*Eleginus navaga*) of Siberia and the Arctic codling (*Boreogadus saida*), both common about Kamchatka, the latter crossing to Greenland.

Several dwarf codfishes having, like the true cod, three dorsal fins and a barbel at the chin are also recorded. Among these are the tomcod, or frostfish, of the Atlantic (*Microgadus tomcod*), the California tomcod (*Microgadus proximus*), and *Micromesistius poutassou* of the Mediterranean. These little cods are valued as pan fishes, but the flesh is soft and without much flavor.

Other cod-like fishes have but two dorsals and one anal fin. Many of these occur in deep water. Among those living near shore, and therefore having economic value, we may mention a few of the more prominent. The codlings (*Urophycis*) are represented by numerous species on both shores of the Atlantic.

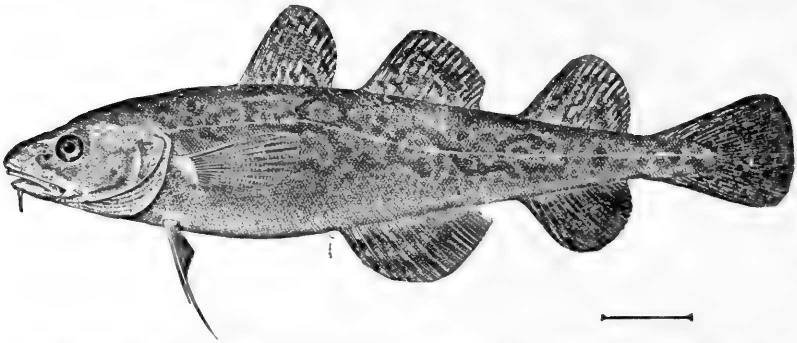


Fig. 489.—Tomcod, *Microgadus tomcod* (Walbaum). Wood's Hole, Mass.

Urophycis blennoides is common in the Mediterranean. *Urophycis regius*, on our South Atlantic coast, is said to exhibit electric powers in life, a statement that needs verification. In the Gulf of Mexico *Urophycis floridanus* is common. Farther north are the more important species *Urophycis tenuis*, called the white hake, and *Urophycis chuss*, the squirrel-hake. The ling (*Molva molva*) is found in deep water about the North Sea.

A related genus, *Lota*, the burbot, called also ling and, in America, the lawyer, is found in fresh waters. This genus contains the only fresh-water members of the group of *Anacanthini*.

The European burbot, *Lota lota*, is common in the streams and lakes of northern Europe and Siberia. It is a bottom fish, coarse in flesh and rather tasteless, eaten sometimes when boiled and soaked in vinegar or made into salad. It is dark olive in color, thickly marbled with blackish.

The American burbot, or lawyer (*Lota maculosa*), is very much like the European species. It is found from New England throughout the Great Lakes to the Yukon. It reaches a length of usually two or three feet and is little valued as food in the United States, but rises much in esteem farther north. The liver and roe are said to be delicious. In Siberia its skin

is used instead of glass for windows. In Alaska, according to Dr. Dall, it reaches a length of six feet and a weight of sixty pounds.

FIG. 490.—Burbot, *Lota maculosa* (Le Sueur). New York.

The rocklings (*Gaidropsarus* and *Enchelyopus*) have the first dorsal composed of a band of fringes preceded by a single ray. The species are small and slender, abounding chiefly in the Mediterranean and the North Atlantic. The young have been

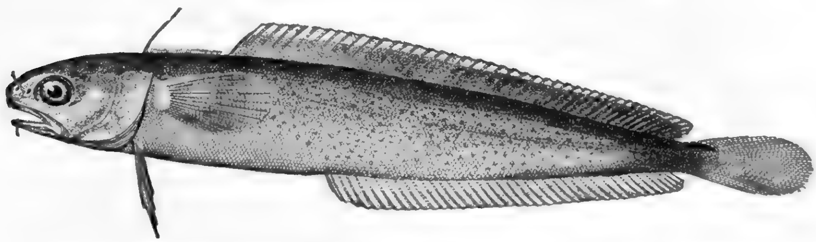


FIG. 491.—Four-bearded Rockling, *Enchelyopus cimbrius* (Linnæus). Nahant, Mass.

called "mackerel-midges." Our commonest species is *Enchelyopus cimbrius*, found also in Great Britain.

The cusk, or torsk, *Brosme brosme*, has a single dorsal fin only. It is a large fish found on both shores of the North Atlantic, but rather rare on our coasts.

Fossil codfishes are not numerous. Fragments thought to belong to this family are found in English Eocene rocks.

Nemopteryx troscheli, from the Oligocene of Glarus, has three dorsal fins and a lunate caudal fin. Other forms have been referred with more or less doubt to *Gadus*, *Brosmius*, *Strinsia*, and *Melanogrammus*.

Gill separates the "three-forked hake" (*Raniceps trifurcus*) of northern Europe as a distinct family, *Ranicipitidæ*. In this species the head is very large, broad and depressed, differing in this regard from the codlings and hakes, which have also

two dorsal fins. The deep-water genus, *Bathyonus*, is also regarded as a distinct family, *Bathyonidæ*.

The Hakes: Merluciidæ.—Better defined than these families is the family of hakes, *Merluciidæ*. These pike-like codfishes have the skull peculiarly formed, the frontal bones being paired, excavated above, with diverging crests continuous forward from the forked occipital crest. The species are large fishes,

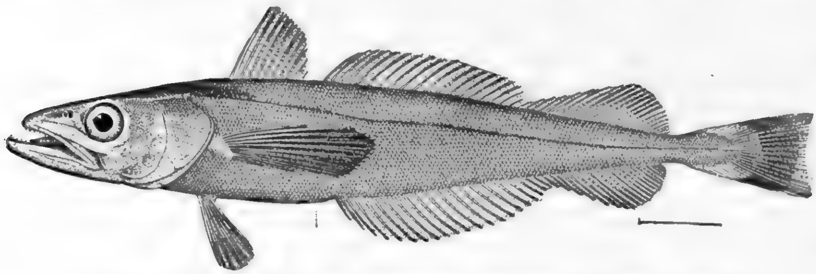


FIG. 492.—California Hake, *Merluccius productus* (Ayres). Seattle.

very voracious, without barbels, with the skeleton papery and the flesh generally soft. The various species are all very much alike, large, ill-favored fishes with strong teeth and a ragged appearance, the flesh of fair quality. *Merluccius merluccius*, the hake or stock-fish, is common in Europe; *Merluccius bilinearis*, the silver hake, is common in New England, *Merluccius productus* in California, and *Merluccius gayi* in Chile.

The Grenadiers: Macrouridæ. — The large family of grenadiers, or rat-tails, *Macrouridæ*, is confined entirely to the oceanic

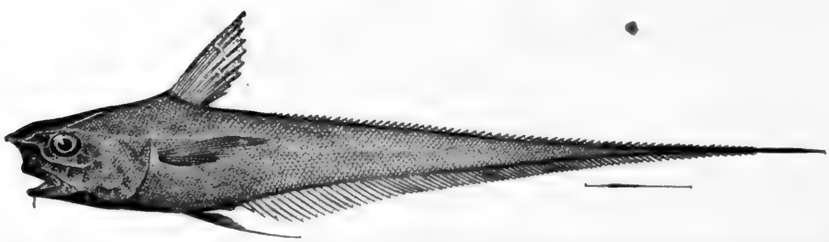


FIG. 493.—*Coryphænoides carapinus* (Goode & Bean), showing leptoceral tail. Gulf Stream.

depths, especially of the north Atlantic and Pacific. The head is formed much as in the codfishes, with usually a barbel at the chin. There are two dorsals, the second like the anal being low, but the leptocercal tail is very long and tapering, ending in a fila-

ment without caudal fin. The scales are usually rough and spinous. The species are usually large in size, and dull gray or black in color.

The best-known genus is *Macrourus*. *Macrourus berglax* is found on both shores of the north Atlantic. *Macrourus*

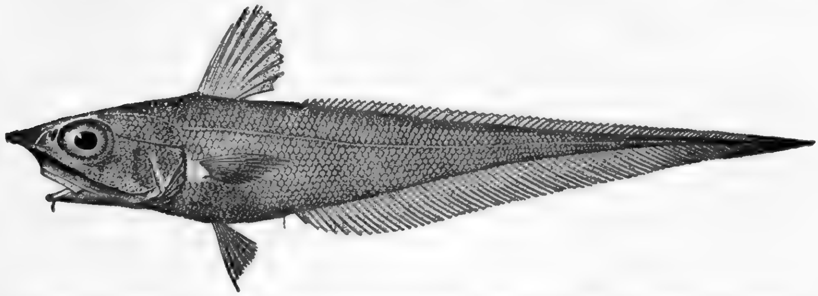


FIG. 494.—Grenadier, *Cœlorhynchus carminatus* Goode & Bean. Martha's Vineyard.

bairdi is abundant in off-shore dredgings from Cape Cod to Cuba. *Macrourus cinereus*, the pop-eye grenadier, outnumbers all other fishes in the depths of Bering Sea. *Cœlorhynchus japonicus* is often taken by fishermen in Japan. *Coryphænoides rupestris* is common in the north Atlantic. *Bogoslovius clarki* and

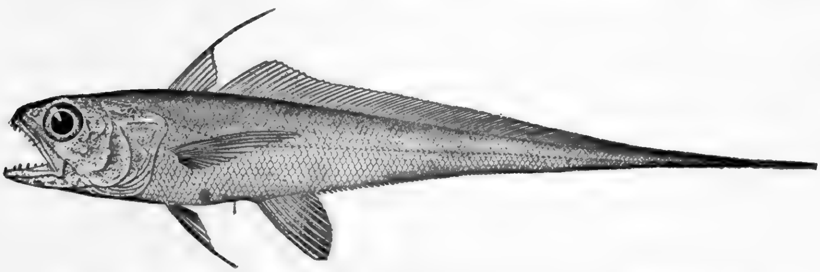


FIG. 495.—*Steindachnerella argentea* (Goode & Bean). Gulf Stream.

Albatrossia pectoralis were dredged by the *Albatross* about the volcanic island of Bogoslof. *Trachyrhynchus trachyrhynchus* is characteristic of the Mediterranean. *Nematonurus goodei* is common in the Gulf Stream, and *Dolloa longifilis* is found off Japan. Other prominent genera are *Bathygadus*, *Gadomus*, *Regania*, and *Steindachnerella*.

The *Murænolepidæ* are deep-sea fishes, with minute eel-like scales, and no caudal fin. The ventrals are five-rayed and there are 10 pterygials.

CHAPTER XXXI

ORDER PEDICULATI: THE ANGLERS

THE Angler-fishes.—The few remaining fishes possess also jugular ventral fins, but in other regards they show so many peculiarities of structure that we may well consider them as forming a distinct order, *Pediculati* (*pedicula*, a foot-stalk), although the relation of these forms to the *Batrachoididæ* seems a very close one.

The most salient character of the group is the reduction and backward insertion of the gill-opening, which is behind the pectoral fins, not in front of them as in all other fishes. The hypocoracoid and hypercoracoid are much elongate and greatly changed in form, so that the pectoral fin is borne on the end of a sort of arm. The large ventrals are similarly more or less exserted. The spinous dorsal is much reduced, the first spine being modified to form a so-called fishing-rod, projecting over the mouth with a fleshy pad, lure, or bait at its tip. The form of the body varies much in the different families. The scales are lost or changed to prickles and the whole aspect is very singular, and in many cases distinctly frog-like. The species are mostly tropical, some living in tide-pools and about coral reefs, some on sandy shores, others in the oceanic abysses.

The nearest allies of the Pediculates among normal fishes are probably the *Batrachoididæ*. One species of *Lophiidæ* is recorded among the fossils, *Lophius brachysomus*, from the Eocene of Monte Bolca. No fossil *Antennariidæ* are known. Fossil teeth from the Cretaceous of Patagonia are doubtfully named "*Lophius patagonicus*."

The Fishing-frogs: Lophiidæ.—In the most generalized family, that of the fishing-frogs (*Lophiidæ*), the body is very much depressed, the head the largest part of it. The mouth is excessively wide, with strong jaw-muscles, and strong sharp teeth.

The skin is smooth, with dermal flaps about the head. Over the mouth, like a fishing-rod, hangs the first dorsal spine with a lure at the tip. The fishes lie flat on the bottom with sluggish movements except for the convulsive snap of the jaws. It has been denied that the bait serves to attract small fishes to their destruction, but the current belief that it does so is certainly plausible. As to this Dr. Gill observes:

"The name 'angler' is derived from the supposition that by means of the foremost dorsal spine, which bears leaf-like tags, or appendages, at the end, it angles for fishes itself, lying upon the ground with its head somewhat upraised. According to Mr. S. Kent, however, this is at most only partly the case: 'That the fish deliberately uses this structure as a fisherman does his rod and line for the alluring and capture of other fish is a matter of tradition handed down to us from the time of Pliny and Aristotle, and which scarcely any authority since their time has ventured to gainsay. Nevertheless, like many of the delightful natural-history romances bequeathed to us by the ancient philosophers, this one of the angler-fish will have to be relegated to the limbo of disproved fiction. The plain and certain ground of facts, all the same, has frequently more startling revelations in store for us than the most fervid imaginations of philosophers, and that this assertion holds good in the case now under consideration must undoubtedly be admitted. It is here proposed to show, in fact, that the angler is one of the most interesting examples upon which Nature has exercised her handicraft, in the direction of concealing the identity of her protégé, such ingenuity being sometimes utilized with the object of protecting the organism from the attacks of other animals, or, as illustrated in the present instance, for the purpose of enabling it by stealth to obtain prey which it lacks the agility to hunt down after the manner of ordinary carnivorous fishes. To recognize the several details here described, it will not suffice to refer to examples simply, and usually most atrociously stuffed, nor even to those preserved in spirit, in which all the life colors are more or less completely obliterated and the various membranous appendages shrunk up and distorted. In place of this, a healthy, living example fresh from the sea, or, better still, acclimatized in the tanks of an aquarium, must be

attentively examined, and whereupon it will be found that this singular fish, throughout the whole extent of its superficies, may be appropriately designated a living sham."

It was, in the first place, observed by Mr. Kent "that the fish while quietly reclining upon the bottom of its tank presented a most astonishing resemblance to a piece of inert rock, the rugose prominences in the neighborhood of the head lending additional strength to this likeness. This resemblance being recognized, it was next found, on a little closer inspection, that the fish constituted, in connection with its color, ornamentations, and manifold organs and appendages, the most perfect facsimile of a submerged rock, with that natural clothing of sedentary animal and vegetable growths common to boulders lying beneath the water in what is known as the laminarian zone. In this manner the numerous simple or lobulated membranous structures dependent from the lower jaw and developed as a fringe along the lateral line of the body imitate with great fidelity the little flat calcareous sponges (*Grantia*), small compound ascidians, and other low organized zoophytic growths that hang in profusion from favorably situated submarine stones. That famous structure known as the angler's 'rod and bait' finds its precise counterpart in the early growing phase of certain sea-plants, such as the oarweed (*Laminaria*), while the more posterior dorsal fin-rays, having short lateral branchlets, counterfeit in a like manner the plant-like hydroid zoophytes known as *Sertulariæ*. One of the most extraordinary mimetic adaptations was, however, found in connection with the eyes, structures which, however perfectly the surrounding details may be concealed, serve, as a rule, to betray the animal's presence to a close observer. In the case of the angler, the eyes during life are raised on conical elevations the sides of which are separated by darker longitudinal stripes into symmetrical regions, the structure, as a whole, with its truncated summit upon which the pupil opens, reproducing with the most wonderful minuteness the multivalve shell of a rock barnacle (*Balanus*). To complete the simile the entire exposed surface of the body of the fish is mapped out by darker punctated lines into irregular polygonal areas, whose pattern is at once recognized by the student of marine zoology as corresponding with that of the

flat, cushion-like expansions of the compound tunicate *Botryllus violaceus*. Thus disguised at every point, the angler has merely to lie prone, as is its wont, among the stones and débris at the bottom of the sea and to wait for the advent of its unsuspecting prey, which, approaching to browse from what it takes to be a flat rock—differing in no respect from that off which it obtained the last appetizing morsel of weed or worm—finds itself suddenly engulfed beyond recall within the merciless jaws of this marine impostor."

The great fishing-frog of the North Atlantic, *Lophius piscatorius*, is also known as angler, monkfish, goosefish, allmouth,

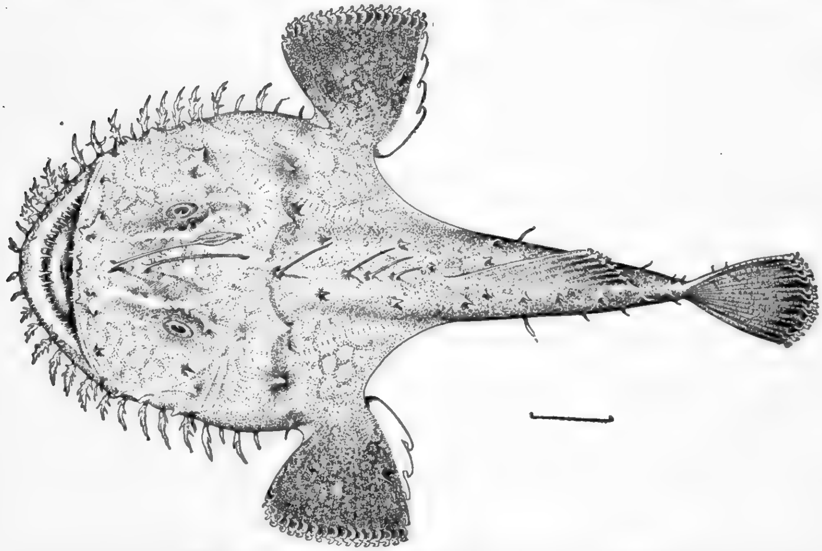


FIG. 496.—Anko or Fishing-frog, *Lophius litulon* (Jordan). Matsushima Bay, Japan.

wide-gape, kettleman, and bellows-fish. It is common in shallow water both in America and Europe, ranging southward to Cape Hatteras and to the Mediterranean. It reaches a length of three feet or more. A fisherman told Mr. Goode that "he once saw a struggle in the water, and found that a goosefish had swallowed the head and neck of a large loon, which had pulled it to the surface and was trying to escape. There is authentic record of seven wild ducks having been taken from the stomach of one of them. Slyly approaching from below, they seize birds as they float upon the surface."

"The angler, or goosefish, spawns in summer along the eastern Atlantic coast, and the result of its labor is quite remarkable. 'The eggs are very numerous, inclosed in a ribbon-shaped gelatinous mass, about a foot in width and thirty or forty feet long, which floats near the surface. One of these ribbons will weigh perhaps forty pounds, and is usually partially folded together and visible a foot or eighteen inches from the top of the water, its color being brownish purple. The number of eggs in one of these has been estimated to be from forty to fifty thousand.' The growth of the young after exclusion from the egg is rather rapid, and Professor Goode saw 'young fish two or three inches long' while others were yet spawning, and these young fish were presumably the fry of those that had spawned the same year, only somewhat earlier. In a few days after hatching they present a striking appearance on account of the enormous development of the pectoral and ventral fins."

Aristotle gives, according to Professor Horace A. Hoffman, this account of the angler: "'Inasmuch as the flat, front part is not fleshy, nature has compensated for this by adding to the rear and the tail as much fleshy substance as has been subtracted from the front.' The *βάτραχος* is called the angler. He fishes with the hair-like filaments hung before his eyes. On the end of each filament is a little knob, just as if it had been placed there for a bait. He makes a disturbance in sandy or muddy places, hides himself and raises these filaments. When the little fish strikes at them he leads them down with the filaments until he brings them to his mouth. The *βάτραχος* is one of the *σελάχη*. All the *σελάχη* are viviparous or ovoviviparous except the *βάτραχος*. The other flat *σελάχη* have their gills uncovered and underneath them, but the *βάτραχος* has its gills on the side and covered with skinny opercula, not with horny opercula like the fish which are not *σελαχώδη*. Some fishes have the gall-bladder upon the liver, others have it upon the intestine, more or less remote from the liver and attached to it by a duct. Such are *βάτραχος, ἔλλοψ, συνάγρίς, σμύραινα*, and *ξιφίας*. The *βάτραχος* is the only one of the *σελάχη* which is oviparous. This is on account of the nature of its body, for it has a head many times as large as the rest of its body, and spiny and very rough. For this same

reason it does not afterwards admit its young into itself. The size and roughness of the head prevent them both from coming out (i.e., being born alive) and from going in (being taken into the mouth of the parent). The βάτραχος is the most prolific of the σελάχη, but it is scarce because the eggs are easily destroyed, for it lays them in a bunch near the shore."

The genus *Lophius* of northern range has a vertebral column of about thirty vertebræ. *Lophius litulon* occurs in Japan. In the North Pacific is found *Lophiomus*, similar in appearance but smaller in size, ranging southward to the equator, a southern fish having but eighteen vertebræ. *Lophiomus setigerus* is the common anko of Japan, and other species are recorded from Hawaii and the Galapagos.

The Sea-devils: Ceratiidæ.—The sea-devils, or *Ceratiidæ*, are degenerate anglers of various forms, found in the depths of the arctic seas. The body is compressed, the mouth vertical; the substance is very soft, and the color uniform black. Dr. Günther thus speaks of them:

"The bathybial sea-devils are degraded forms of *Lophius;* they descend to the greatest depths of the ocean. Their bones

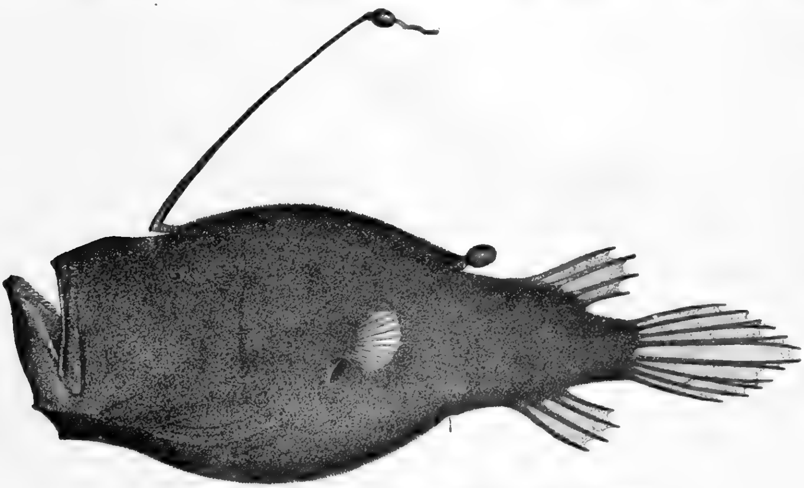


Fig. 497.—*Cryptopsaras couesi* Gill. Gulf Stream.

are of an extremely light and thin texture, and frequently other parts of their organization, their integuments, muscles, and intestines are equally loose in texture when the specimens are

brought to the surface. In their habits they probably do not differ in any degree from their surface representative, *Lophius.*

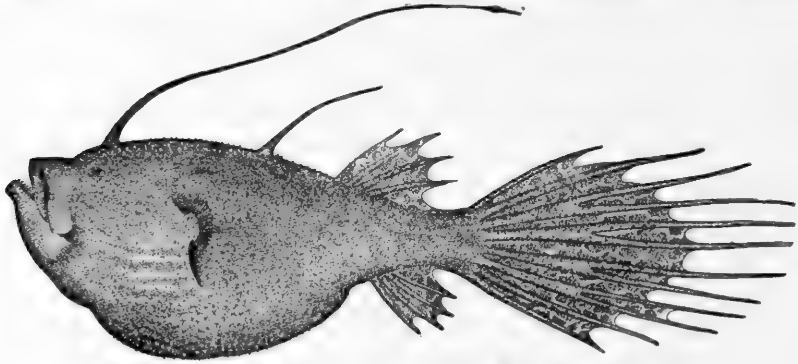


Fig. 498.—Deep-sea Angler, *Ceratias holbolli* Kröyer. Greenland.

The number of the dorsal spines is always reduced, and at the end of the series of these species only one spine remains, with a simple, very small lamella at the extremity (*Melanocetus john-*

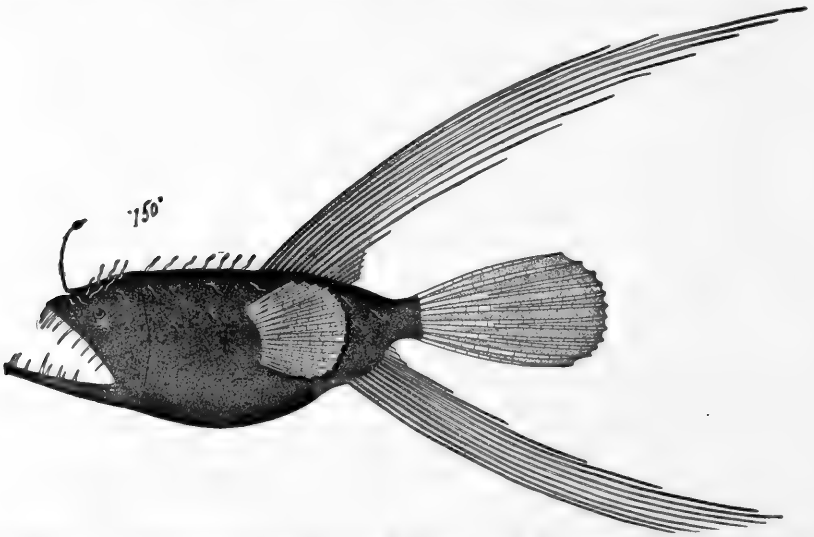


Fig. 499.—*Caulophryne jordani* Goode & Bean. Gulf Stream. Family *Ceratiidæ.*

sonii, Melanocetus murrayi). In other forms sometimes a second cephalic spine, sometimes a spine on the back of the trunk, is preserved. The first cephalic spine always retains the original function of a lure for other marine creatures, but to render it more effective a special luminous organ is sometimes

developed in connection with the filaments with which its extremity is provided (*Ceratias bispinosus*, *Oneirodes eschrichtii*). So far as known at present these complicated tentacles attain to the highest degree of development in *Himantolophus* and *Ægæonichthys*. In other species very peculiar dermal appendages are developed, either accompanying the spine on the back or replacing it. They may be paired or form a group of three, are pear-shaped, covered with common skin, and perforated at the top, a delicate tentacle sometimes issuing from the foramen."

Of the fifteen or twenty species of *Ceratiidæ* described, none

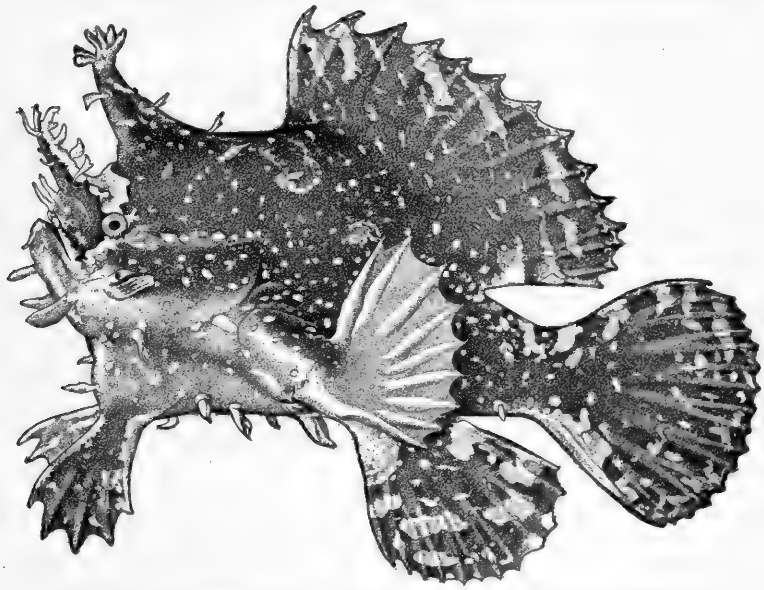


FIG. 500.—Sargassum-fish, *Pterophryne tumida* (Osbeck), Florida. Family *Antennariidæ*.

are common and all are rare catches of the deep-sea dredge. *Caulophryne jordani* is remarkable for its large fins and the luminous filaments, *Linophryne lucifer* for its large head, and *Corynolophus reinhardti* (Fig. 143, Vol. I) for its luminous fishing-bulb.

The Frogfishes: Antennariidæ.—The frogfishes, *Antennariidæ*, belong to the tropical seas and rarely descend far below the surface. Most of them abound about sand-banks or coral reefs, especially along the shores of the East and West Indies, where they creep along the rocks like toads. Some are pelagic, drifting

about in floating masses of seaweed. All are fantastic in form and color, usually closely imitating the objects about them. The body is compressed, the mouth nearly vertical, and the skin either prickly or provided with fleshy slips.

The species of *Pterophryne* live in the open sea, drifting with the currents in masses of sargassum. Two species, *Pterophryne tumida* and *Pterophryne gibba*, are found in the West Indies and Gulf Stream. Two others very similar, *Pterophryne histrio* and *Pterophryne ranina*, live in the East Indies and drift in the Kuro

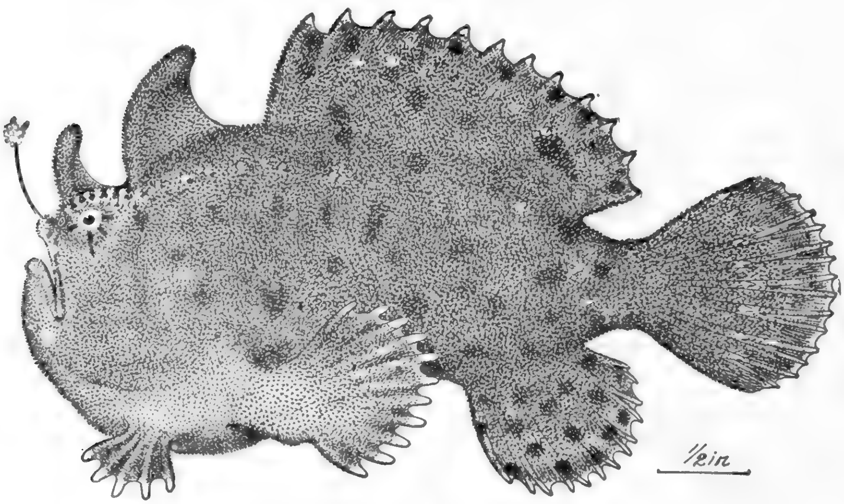


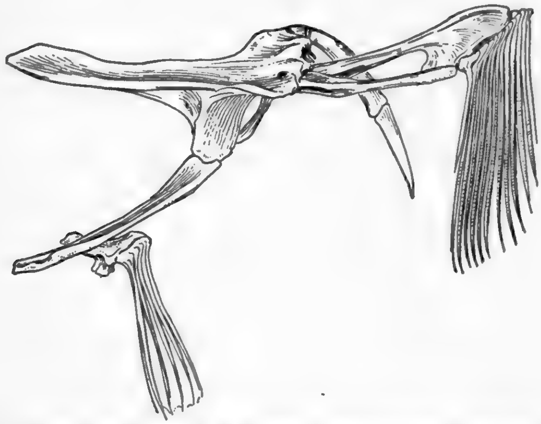
FIG. 501.—Fishing-frog, *Antennarius nox* Jordan. Wakanoura, Japan.

Shiwo of Japan. All these are light olive-brown with fantastic black markings.

The genus *Antennarius* contains species of the shoals and reefs, with markings which correspond to the colors of the rocks. These fishes are firm in texture with a velvety skin, and the prevailing color is brown and red. There are many species wherever reefs are found. *Antennarius ocellatus*, the pescador, is the commonest West Indian species. *Antennarius multiocellatus*, with many ocellated spots, is the Martin Pescador of Cuba, also common.

On the Pacific coast of Mexico the commonest species is *Antennarius strigatus*. In Japan, *Antennarius tridens* abounds everywhere on the muddy bottoms of the bays. *Antennarius*

nox is a jet-black species of the Japanese reefs, and *Antennarius sanguifluus* is spotted with blood-red in imitation of coralline patches. Many other species abound in the East Indies and in



[Fig. 502.—Shoulder-girdle of a Batfish, *Ogcocephalus radiatus* (Mitchill).

Polynesia. The genus *Chaunax* is represented by several deep-water species of the West Indies, Japan, etc.

The *Gigactinidæ* of the deep seas differ from the *Ogcocephalidæ*, according to Boulenger, in the absence of ventrals.

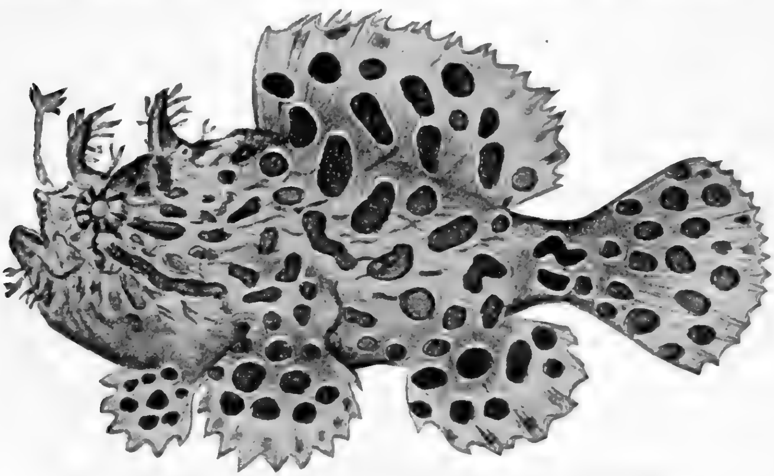


Fig. 503.—Frogfish, *Antennarus scaber* (Cuvier). Puerto Rico.

The Batfishes: Ogcocephalidæ.—The batfishes, *Ogcocephalidæ*, are anglers with the body depressed and covered with hard bony warts. The mouth is small and the bony bases of the

pectoral and ventral fins are longer than in any other of the anglers. The species live in the warm seas, some in very shallow water, others descending to great depths, the deep-sea forms being small and more or less degenerate. These walk along like toads on the sea-bottoms; the ventrals, being jugular, act as fore legs and the pectorals extend behind them as hind legs.

The common sea-bat, or diablo, of the West Indies, *Ogcocephalus vespertilio*, is dusky in color with the belly coppery red. It reaches the length of a foot. The angling spine is very short, hidden under the long stiff process of the snout. Farther north

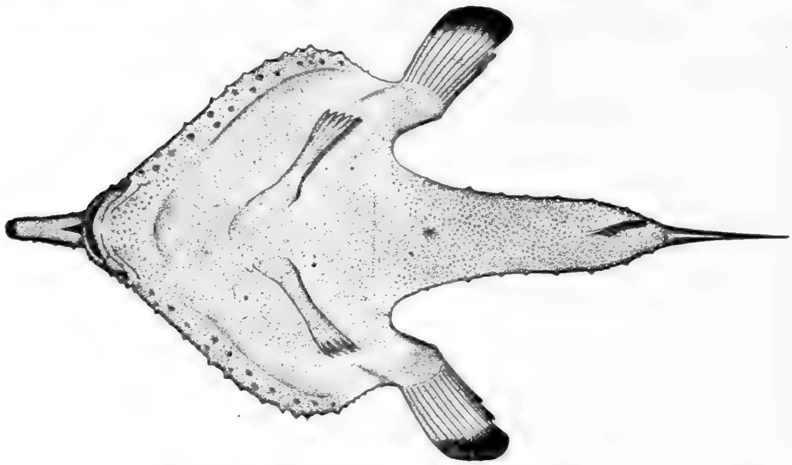


FIG. 504.—*Ogcocephalus vespertilio* (L.). Florida.

occurs the short-nosed batfish, *Ogcocephalus radiatus*, very similar, but with the nostril process, or snout, blunt and short. *Zalieutes elater*, with a large black eye-like spot on each side of the back, is found on the west coast of Mexico. In deeper water are species of *Halieutichthys* in the West Indies and of *Halieutæa* in Japan. *Dibranchus atlanticus* has the gills reduced to two pairs. *Malthopsis* consists of small species, with the rostrum prominent, like a bishop's miter. Two species are found in the Pacific, *Malthopsis mitrata* in Hawaii and *Malthopsis tiarella* in Japan.

And with these dainty freaks of the sea, the results of centuries on centuries of specialization, degeneration, and adaptation, we close the long roll-call of the fishes, living and dead

And in their long genealogy is enfolded the genealogy of men and beasts and birds and reptiles and of all other back-boned animals of whom the fish-like forms are at once the ancestors, the cousins, and the younger brothers. When the fishes of the Devonian age came out upon the land, the potentiality of the

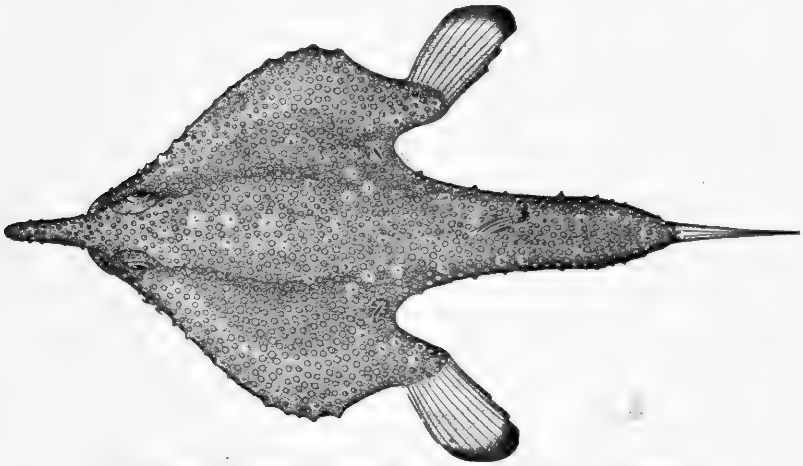


Fig. 505.—Batfish, *Ogcocephalus vespertilio* (L.). Florida.

higher methods of life first became manifest. With the new conditions, more varied and more exacting, higher and more varied specialization was demanded, and, in response to these new conditions, from a fish-like stock have arisen all the birds and beasts and men that have dwelt upon the earth.

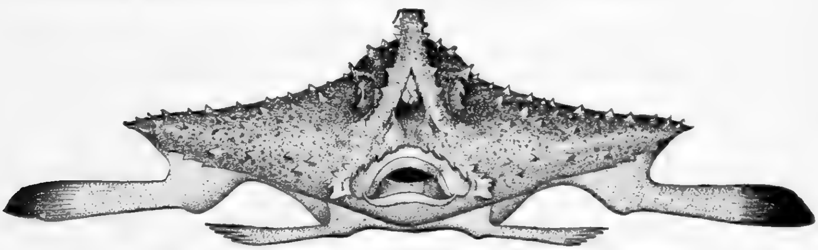


Fig. 506.—Batfish, *Ogcocephalus vespertilio* (Linnæus). Carolina Coast.

THE END.

INDEX

* This family should stand as *Histiopteridæ*, the name *Pentaceros*, *Pentacerotidæ*, being used earlier for starfishes.